POWER PLANT ENGINEERING

GENERATION, TRANSMISSION AND UTILIZATION OF STEAM, ELECTRIC, DIESEL AND HYDRAULIC POWER

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THE GREAT BARRIER

GRAND COULEE DAM is growing. Here is a late photograph, one taken on October 3rd, showing progress in the construction of the great dam. The west wing of the Grand Coulee power plant can be seen below the dam in the foreground. This wing of the power plant will be completed ahead of its twin on the east bank. Each of these wings will contain nine 150,000 hp. turbine generators. The total rated capacity of the 18 units, therefore, will be 2,700,000 hp., making the plant, by far, the largest in the world. This compares with 1,835,000 hp. the total ultimate capacity of Boulder Dam and 750,000 hp. at Dnieprostroy in Russia, the two next largest hydro-electric stations in the world. ¶The dam will be 4300 ft. long at the crest and about 3000 ft. long at the base; about 500 ft. thick at the base and 30 ft. thick at the crest. The crest will rise about 550 ft. above the lowest point of bedrock. The water surface above the dam will be raised about 355 ft. above low water level. ¶The dam will contain 11,500,000 cubic yards of concrete, sufficient to build a monument a hundred feet square and five and three-quarters miles high—enough to cover a city block to a depth of 3375 ft., 2.7 times the height of the Empire State Building. The weight of the concrete will exceed 25,000,000 tons. The dam will create a reservoir 151 miles long averaging 4000 ft. in width, having a maximum depth of 375 ft. ¶Grand Coulee staggers the imagination. It is the greatest thing man has ever done and probably will hold that record for a long time to come. The significance of the dam, however, is not to be found alone in its magnitude nor in the workmanship going into its construction; it lies, rather, in the ends which are to be served. Contrasted with the billions now being spent in the world for the wanton destruction of the property and lives of millions of helpless people, Grand Coulee stands as a monument to the beneficent forces in our civilization. It is our greatest achievement in conservation.

WITH THE EDITORS

Starting Difficulties

IT HAS long been the ambition of the editors of POWER PLANT ENGINEERING that they would be privileged to publish an article relating the experiences of engineers in getting an important plant or unit started into regular service. Everybody knows that mistakes are made in some of the details of design of nearly every large power plant, particularly if equipment of new or changed design is installed. Yet mighty few engineers, power plant executives or manufacturing companies have the desire to permit publication of even the slightest difficulties operating enginers have in getting new equipment to operate up to or better than specifications. No matter how proud they may be of the final results accomplished, the difficulties encountered in working out the final design or adjustments must remain a dark secret passed on only to friends in a confidential manner.

To those who have followed the description of the Delray Extension, which has been published in serial form through the past several months, no doubt many questions regarding the practicability of various points of design have arisen. In this issue Mr. Benjamin presents an extremely frank and complete statement of the major and somewhat unusual difficulties that have been encountered in bringing the plant into regular operation. That in all essentials the equipment meets the design expectations speaks highly for the engineering department of The Detroit Edison Co. and the manufacturers who supplied the equipment. That only slight revisions in details have been necessary to correct operating conditions is an indication that engineers are now capable of employing new principles and materials with a high degree of assurance that their predictions are accurate.

Law Abiding Prisoners

WHEN the detective is given the assignment of catching a particular individual in the act of committing a crime, he arranges to shadow the suspect—trace his movements every minute of the day. Not a single act must escape observation and analysis for motive. The power plant is a cleverly designed prison for heat units, not necessarily dangerous criminals when they escape but they are extremely elusive and their freedom means an enormous national loss annually.

Perhaps the engineer could take a leaf from the detective's book of instructions in tracing these slippery heat units from the fuel to the power line to see that every step in the process is under guard and all prisoners are headed in the right direction. No engineer will question that the paths of heat units through a power plant are as crooked and divided as a grape vine and at every turn and joint some force of nature acting as an accomplice assists the prisoners to escape.

As a prison guard the engineer would do well to provide himself with a chart of paths the heat unit should travel and the points where escape is possible, and at each of these points place detectors and snares that will stop as far as possible all escape.

Each plant, of course, is a different problem but there are a few common points that always need attention. In the furnace, the conversion of the latent energy in the fuel into active heat energy in the boiler water offers several opportunities for escape. Combustible may get into the ash pit; combustible gases may escape up the chimney; more air than necessary may be used for combustion carrying heat to atmosphere; furnace and boiler walls may allow heat to radiate to the boiler room air; soot, scale or slag on heating surfaces may retard heat transmission to boiler water; improper or fallen baffles may allow useful heat to escape to the chimney.

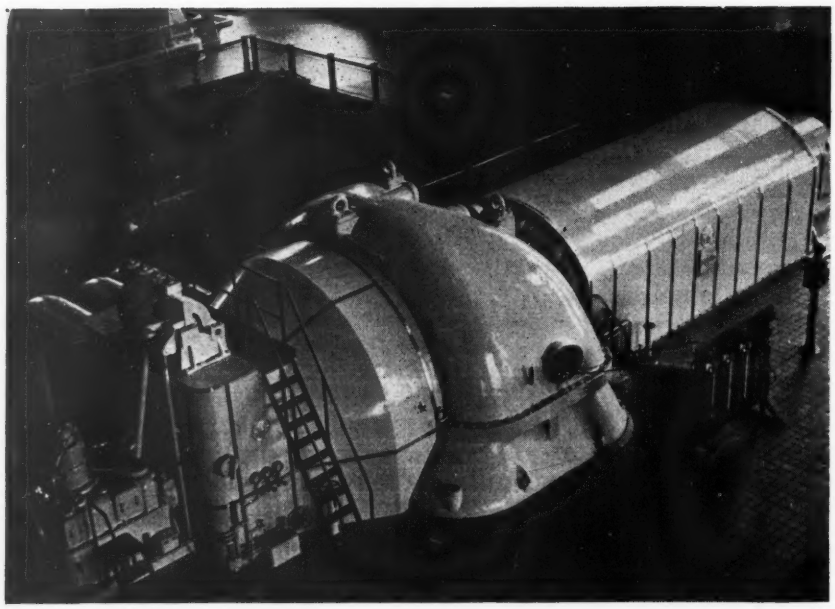
This rather long list of alleys down which heat units may escape is only representative of opportunities offered by other main units in the plant. All along the road may be observed preventable escapes, some perhaps so expensive to eliminate completely that it is economy to let the small amount go, others may be stopped entirely with economy. Again there are places, such as energy conversion points, where great losses occur and scientists have failed to find a recovery scheme.

The great advantage the engineer has over the detective in tracing his suspect is the fact that heat units are strictly law abiding, they never deviate. To be successful, therefore, the engineer must know the laws and direct his prisoners accordingly.

Power Output at All-Time High

DURING the early months of 1939, the electric power output of the utilities throughout the country followed closely the 1937 curve and was better than the 1938 curve, by an average of about 12 per cent. By September, however, an all-time high was reached around 15 per cent better than 1938 and 8 per cent above 1937.

That power executives do not consider the rise in power demand a temporary war-time condition which could be handled by present capacity is evidenced by an increasing number of plans for new plants and extension and actual orders for large boilers and turbo-generating units. Demands for power must be met, but war-time measures, when forced upon private industries, are usually temporary expedients, not the type of plants going into the construction stage by the utilities. They are expecting the increased loads to remain permanently.



Main Turbo-generator at Delray PH 3, 75,000 Kw

High-Pressure Extension of Detroit Edison's DELRAY PLANT

By
MAX W. BENJAMIN
Engineering Division,
The Detroit Edison Co.

Part V. This, the final installment of the series on Delray, publication of which was started in the March issue, relates to operating experiences and gives results secured during initial service

First Ten Months of Operation

IN THE FOUR preceding installments of this series attention has been directed occasionally to the fact that operating convenience has been kept in mind throughout all phases of design. Valves and controls are arranged accessibly; similar units are laid out in repeated patterns based on the construction of satisfactory models; suitable instruments are provided at strategic locations and in adequate number. These and other factors all contribute toward an ease of operation which permits the operating force to concentrate on getting optimum performance from the plant and reduce to a minimum the expenditure of energy and resourcefulness in merely keeping the plant running.

Irrespective of the care that is given a project of this kind in the design and construction stages, however, problems are apt to arise during the early months of operation which require adjustments or changes before the plant is considered really satisfactory. In some of these cases the need for possible alterations in the field is anticipated, and provided for in the design. In other instances the cause of annoyance may be very obscure. In all cases it is common to find operators, designers, and manufacturers working together to effect satisfactory solutions of the problems.

In this final installment of the series some of the problems encountered in operating the new Delray equipment are discussed, and solutions given to those problems for which solutions have been achieved. Certain operating procedures also are outlined.

Experiences in the Turbine Room

SINCE OPERATION in the Delray extension began on December 1, 1938, there have been some operating difficulties with various units of equipment in the turbine room. No forced outages are chargeable to the turbine or generator, but in a few instances problems arising with auxiliary equipment were considered serious.

The turbo-generator has been generally satisfactory, presenting only a few problems of minor consequence. In the initial operation it was at once evident that some further balancing of the unit was required. Vibration of the floor section integral with the turbine base was quite pronounced, especially at the exciter end of the generator. Since the turbine base is independent of the main building structure, the vibrations were not carried into the main floor or to any other part of the building. Balancing of the set, which required only a few days, was accomplished by adding weights to the last stage turbine wheel.

Another item which received attention is the turbine governor. As originally installed the governor "bobbled" excessively; that is, there was a particular action in the governing mechanism which caused the output to fluctuate as much as 4000 kw even at a constant governor setting. The cause of the "bobble" appears to lie either in sticking or vibration in the linkage between the fly-balls and the main pilot valve. At the present time this condition has not been eliminated completely, although considerable improvement resulted from changing the pin-and-bushing connections in the gimbal bearing between the governor spindle and governor beam to connections of the knife-edge type.

Amplitude of the bobble has been reduced to some extent, while the frequency has been retarded to a small fraction of its former value. No further refinements of the governing device are contemplated at the present time. The extent of the bobble before and after the installation of knife-edges in the gimbal bearing is represented by the cards reproduced in Fig. 87.

There has been, and still is, some leakage of steam at the bolted joint in that part of the turbine casing which forms the high-pressure shaft-packing casing. Steam temperature at this joint is in the vicinity of 900 F at all loads, with pressures ranging up to 450 psi g. Attempts to stop the leakage by tightening the bolts have failed and some further steps will be taken, if necessary, when the unit is opened up for inspection. It is possible that nothing more than remaking the joint will be required.

During the early months of operation the temperature of steam furnished to the turbine was considerably below the designed value, as will be discussed later, and when the exhaust hood was opened to permit inspection of the last turbine wheel the buckets showed evidence of erosion just at the ends of the Stellite protection strips. It was thought that extra moisture in the turbine exhaust resulting from the low initial temperature might be responsible for the erosion, and it probably was to some degree. The initial erosion rate always seems to be rather high, however, and with subsequent operation at steam temperatures nearer the design value the erosion has not progressed appreciably.

Two conditions arising from manufacturing tolerances deserve mention in this account. While the turbine is designed for a normal operating back pressure of 1.0 in. Hg absolute, it is understood, of course, that the exhaust pressures actually encountered will

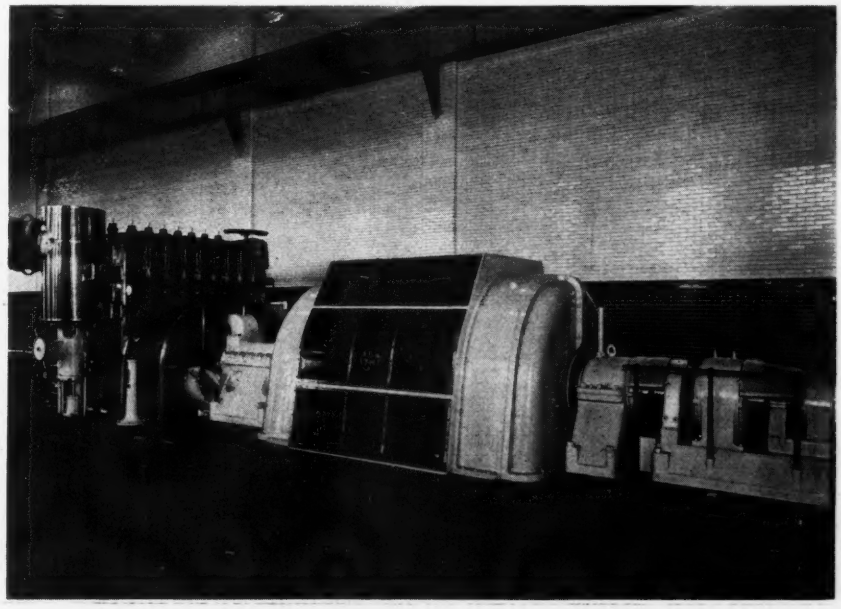


Fig. 84. 10,000-kw superposed turbo-generator installed between the high and low pressure sections of Delray PH 3

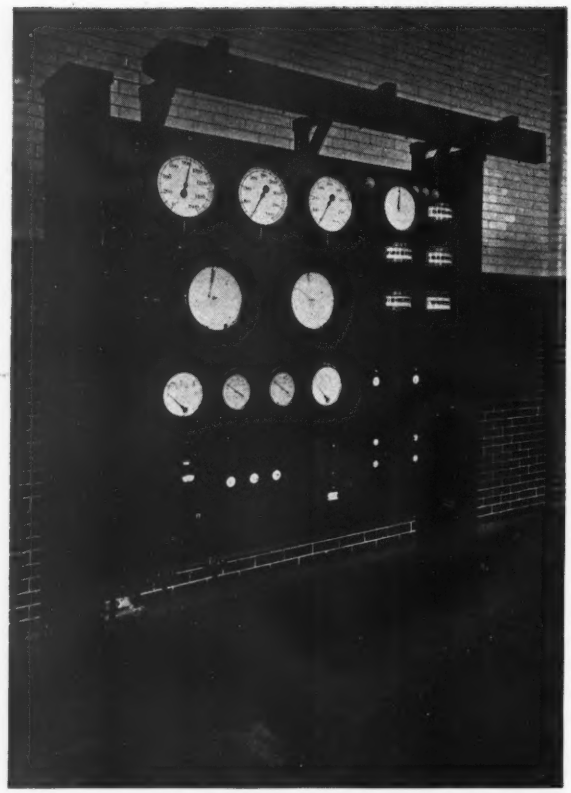


Fig. 85. Operating instruments installed with superposed turbine

vary from 0.3 or 0.4 in. Hg to as much as 2.0 in. Hg, depending upon the season of the year and the load on the machine. The turbo-generator was specified, therefore, to generate 75,000 kw at the generator terminals when the turbine exhaust pressure is 2.0 in. Hg absolute with the unit heating its own feedwater. It was estimated by the turbine engineers that some 652,000 lb per hr of throttle steam flow would be required to develop the specified output. Auxiliary condensate flowing through the main unit feedwater heaters would bring the total feedwater flow to 685,000 lb per hr, and to accommodate surges the venturi meter in the boiler feed line was designed for 790,000 lb per hr. Capacity of the steam admission valves and first stage nozzles actually exceeds the required 652,000 lb per hr and during one period of high load a surge occurred which created sufficient differential over the venturi tube to force the mercury out of the secondary element of the meter. A recurrence of the loss of mercury from the meter has been prevented by adjusting the check valve in the secondary element and by lengthening the U-leg so that a greater differential would be required to force the mercury out of it.

Testing that has been done on the machine to date indicates that for a given steam flow the feedwater heater shell pressures are higher than the designed values. This does not affect operation of the unit in any way except that extraction is somewhat greater than expected and feedwater temperatures run a few degrees high. A complete explanation for this condition has not yet been ascertained although test data indicate that the turbine stage pressures are higher than were expected. It also is possible that the pressure losses in the extraction passages within the turbine and through the bleeder piping are lower than the design estimates, thereby contributing to the discrepancy between the design and actual heater pressures. Here again the deviation from design crowds the limits of the instruments concerned. For example the temperature indicator on the high-pressure heater outlet was designed for 400 F maximum while the expected maximum water temperature was 388 F. Actually, the maximum range of the instrument has been exceeded at high loads because of the high stage pressure, and this indicator, as well as one for the 7th stage heater, is being altered at the present time to add an extra 20 F to their ranges.

Performance data obtained on the turbine during the first two months of operation are compared with the corresponding design data in Table XVI.

Superposed Unit

Installation of the 10,000-kw superposed unit shown in Fig. 84 was scheduled originally for the Spring of 1939, but was not completed for various reasons until Autumn. Actual experience with the superposed unit has been so very limited, therefore, that not much can be said concerning it. Steam first was admitted to the unit on August 21, 1939 when it was brought to a speed of 900 rpm and kept turning at that rate for about a half hour. Following this short run, the machine was shut down for inspection and adjustments before attempting to bring it to full speed.

Bonnet joints on the two throttle valves are of the

TABLE XVI. APPROXIMATE COMPARISON OF DESIGN AND OPERATING PERFORMANCE 75,000-KW TURBO-GENERATOR UNIT 14*

	Design	Operating	Design	Operating	Design	Operating	Design	Operating
Throttle Steam Flow, lb per hr	652,000**	653,200	541,900	541,900	443,700	443,700	198,800	198,800
Steam Pressure at Throttle, Psi G	815	814.2	815	825.7	815	821.2	815	834.6
Steam Temperature at Throttle, F	900	838.1	900	881.9	900	836.4	900	890.3
Exhaust Pressure, In. Hg Abs	1.0	0.712	1.0	0.655	1.0	0.593	1.0	0.358
Temperature of Feedwater Leaving 4th-Stage Heater, F	389.7	397.7	373.5	383.6	357.1	364.2	297.0	308.0
Generator Output, Kw	76,950	74,710	64,500	64,970	53,100	52,220	21,900	24,540
Power Factor, per cent	75	96.0	75	91.8	75	87.3	75	91.5
Heat Rate, Btu per kw hr Generator Output	9,230	9,158	9,285	9,050	9,396	9,192	10,030	9,458

*The design data assume operation with reciprocating dry vacuum pump and with heater-drain pump on 10th-stage heater at all loads.

Actual operation was with steam jet air ejectors, and heater-drain pump was shut down on lowest load.

Operating performance figures have not been corrected to standard throttle and exhaust conditions.

**Maximum design flow.

tongue-and-groove type, made up with gas-filled hollow ring gaskets. Admission valve guides also are mounted on the steam chest with the same type of joint. The hollow joint-rings which are filled with inert gas at a pressure of about 600 psi g are compressed during installation only enough to insure complete contact with the joint faces and to permit the ring to follow the joint faces in case of any distortion of the joint itself.

Almost as soon as steam was admitted to the machine these ring joints in the throttle valve bonnets began to leak. Examination of the rings after the machine was shut down indicated that not enough space had been left between the tongue and the bottom of the groove with the result that when the joint was bolted together the ring cracked open. The gas escaped and the seal was destroyed. For the time being, at least, these joints have been remade with solid monel gaskets.

A desirable change concerned the arrangement of drain piping from the machine. Too many drain lines were connected together with the result that steam was vented into the turbine room instead of being carried away properly. Obviously the remedy here was to provide more ample drain piping and simplify its arrangement. The need for altering the drain lines was recognized in the design stage, but it will be recalled that the turbine was made in England which rendered exchanges of drawings quite time consuming. Because of the complexity of the drain piping, the restricted quarters available for it within the spring-supported turbine base, and the number of exchanges of drawings which probably would have been necessary, it was thought advisable to have the machine come through and rearrange the drain lines in the field.

After the first starting of the machine and the subsequent inspection and changes, the unit was again started on September 1 and brought to full speed. Load of 1500 kw was applied on September 19 and the unit probably will be brought to full load while this article is being printed.

It was pointed out in the first installment of this series that the inherent tendency for two-pole machines to vibrate dictated the adoption and design of a spring-supported base carried on the building steel for the mounting of this unit. This base, which is of massive construction, functions satisfactorily and results in much smoother operation of the machine than was possible to obtain with the unit on its original base before it was rebuilt for superposition.

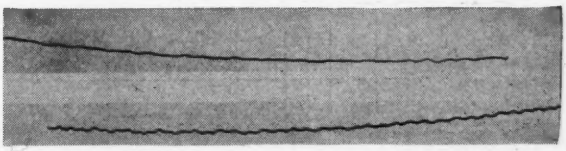


Fig. 87. Cards illustrating governor "bobble". Upper curve shows conditions with knife-edge connections in gimbal bearing. Lower curve shows original conditions with pin-and-bushing connection in gimbal bearing

At the present time there is nothing more that can be reported about the operation of the superposed unit. There is every reason to believe, however, that with a few additional adjustments the unit will be ready for regular operation and will perform essentially as expected.

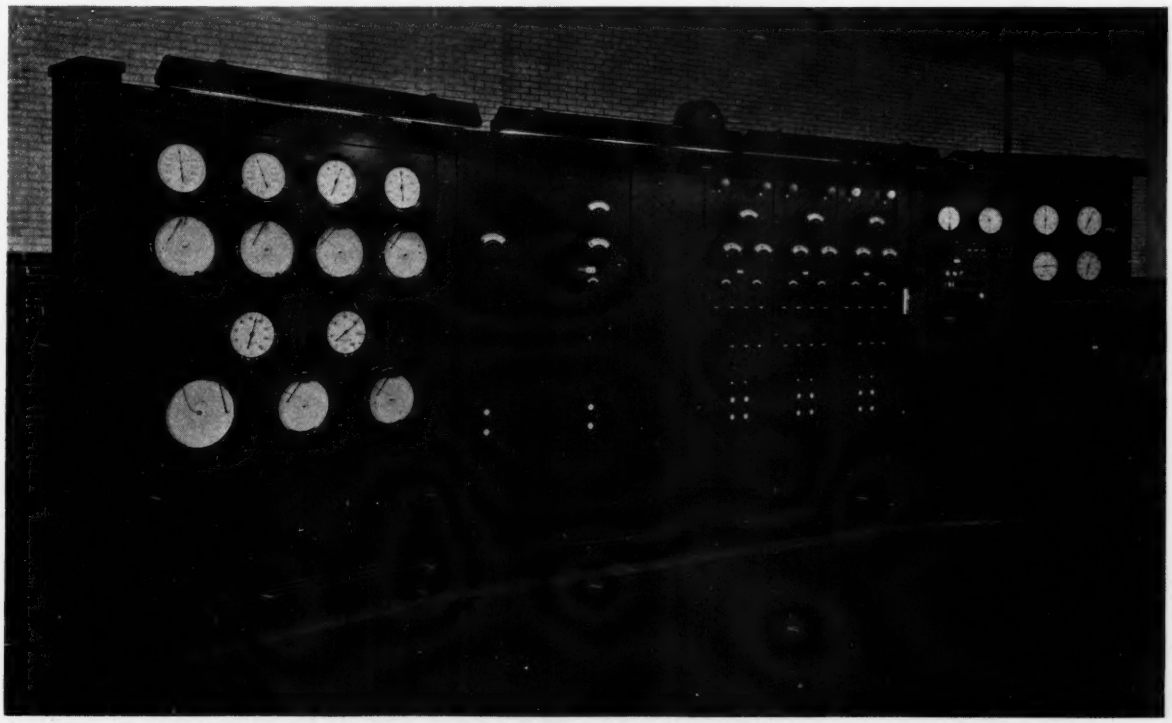


Fig. 86. Main instrument board in the Delray turbine room

Superposed Unit Starting Procedure

Installation of a superposed turbine brings with it certain operating problems not encountered with condensing machines, the problems depending somewhat upon the way in which the superposed unit is intended to function. For that reason it may be of interest to relate some of the highlights of the operating procedure being followed.

As discussed in the section on "Operating Cycle" the superposed turbine exhausts to the main steam header in the low-pressure section of the plant. This arrangement requires a different starting procedure than would be followed if the unit exhausted into one specific low-pressure turbine. In the latter case

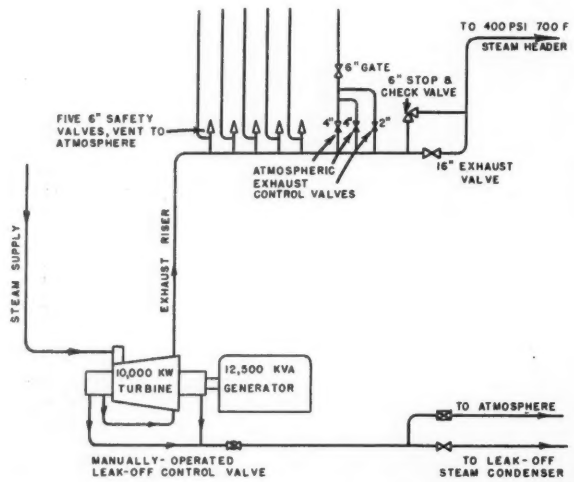


Fig. 88. Diagram of exhaust and leak-off piping on 10,000-kw superposed turbine

arrangements could be made to start the combined unit as a single condensing machine, but with the turbine exhausting into the low-pressure plant header a more complicated starting cycle is necessary.

The sequence of starting operations being tried out is best understood by reference to Fig. 88. Preliminary steps such as warming the turbine lead, opening drain lines, and starting the auxiliary oil pump are, of course, the same as with any other important turbine. The 16-in. main exhaust valve is left closed to prevent a back flow of steam from the 400 psi system, and the 6-in. stop-and-check valve which bypasses the main exhaust valve is put into condition so that it will open when sufficient pressure is reached in the exhaust manifold. Next the three atmospheric-exhaust control valves are opened, providing one 2-in. diameter and two 4-in. diameter vents on the exhaust manifold. Steam is then admitted to the turbine which is allowed to revolve slowly while the exhaust steam passes to atmosphere. When the turbine and exhaust piping have become thoroughly heated, the speed is increased gradually and the exhaust pressure raised by successively closing the two 4-in. valves and then the 2-in. valve. This brings the exhaust pressure to a value that will cause the 6-in. stop-and-check valve to open at which time the machine begins its delivery of steam into the 400 psi 700 F system. The turbine speed is further increased to 3600 rpm, the machine synchronized with the system, and the generator switch closed. All drain valves are then closed and the 16-in. main exhaust valve is opened manually, after which load can be applied to the generator. At a turbine speed of about 500 rpm the shaft packing leak-off line is opened either to atmosphere or, if the 50,000-kw main unit 13 is operating, to the leak-off steam condenser. Under all conditions the shaft-packing leak-off pressure is adjusted to about 1 psi g by means of a hand operated control valve.

Stopping Procedure

When the superposed turbine is to be shut down the sequence of operations is practically the reverse of those in starting. After the load is reduced to zero the 16-in. main exhaust valve is closed, forcing all the no-load exhaust steam to flow into the 400 psi 700 F header through the 6-in. stop-and-check valve. Then one of the 4-in. atmospheric exhaust valves is opened and the throttle valves of the unit tripped shut. The purpose of opening the turbine exhaust to atmosphere is to prevent an excessive temperature rise within the turbine which would result from high windage if the rotor were left to spin in a dense steam atmosphere.

Operation of Booster Pump

The booster feed pump installed with the superposed turbine will not be started until the machine is operating under load. In the meanwhile boiler feed-

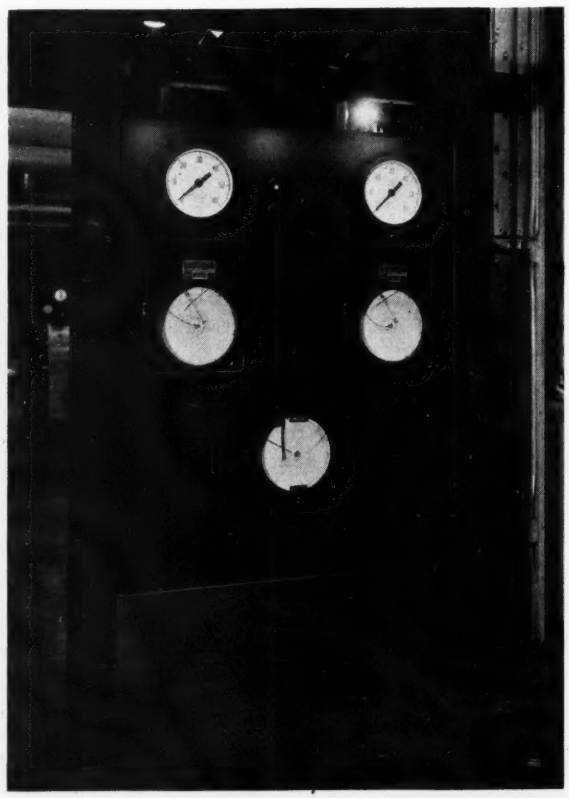


Fig. 89. Pressure gages and flow meters installed for guidance in controlling the booster feed pump

TABLE XVII. APPROXIMATE COMPARISON OF DESIGN AND OPERATING PERFORMANCE FEEDWATER HEATERS, 75,000-KW UNIT 14*

	Design	Operating	Design	Operating	Design	Operating	Design	Operating
Throttle steam Flow, lb per hr	652,000**	653,200	541,900	541,900	443,700	443,700	198,800	198,800
4TH STAGE								
Feedwater through Heater, lb per hr***	652,000	654,600	541,900	544,900	443,700	444,200	198,800	202,800
Heater Shell Pressure, Psi Abs	212.1	235.8	174.3	198.7	141.8	155.3	61.8	72.9
Bled Steam Temperature, F	626.5	568.8	597	574.7	570	530.5	505	484.3
Water Temperature Entering, F	326.0	330.9	312.1	320.5	298.5	306.1	248.0	257.9
Water Temperature Leaving, F	389.7	397.7	373.5	383.6	357.1	364.2	297.0	308.0
Terminal Difference, F	—3.0	—1.9	—3.0	—2.3	—3.0	—3.0	—3.0	—2.3
7TH STAGE								
Feedwater through Heater, lb per hr***	652,000	654,600	541,900	544,900	443,700	444,200	198,800	202,800
Heater Shell Pressure, Psi Abs	97.6	107.5	80.3	89.7	65.3	71.5	28.1	33.2
Bled Steam Temperature, F	514.4	461.4	490	470.1	467	410.6	406	402.4
Water Temperature Entering, F	257.4	258.7	246.6	249.6	234.9	240.9	193.2	200.6
Water Temperature Leaving, F	326.0	330.9	312.1	320.5	298.5	306.1	248.0	257.9
Terminal Difference, F	0.0	2.2	0.0	—0.4	0.0	—1.7	0.0	—1.7
10TH STAGE								
Condensate through Heater, lb per hr***	524,350	518,400	440,500	437,000	363,500	360,200	170,000	202,900
Heater Shell Pressure, Psi Abs	35.33	37.65	29.0	30.11	23.8	24.83	10.7	11.14
Bled Steam Temperature, F	293	261.1	274	264.7	255	240.1	203	209.5
Water Temperature Entering, F	173.3	171.0	165.5	163.8	156.7	157.4	126.0	129.6
Water Temperature Leaving, F	256.8	257.3	246.0	247.9	234.3	239.0	192.6	197.6
Terminal Difference, F	3.0	6.3	3.0	2.7	3.0	0.7	3.0	0.8
13TH STAGE								
Condensate through Heater, lb per hr***	524,350	518,400	440,500	437,000	363,500	360,200	170,000	202,900
Heater Shell Pressure, Psi Abs	7.25	6.70	6.06	5.66	4.94	4.66	2.29	2.27
Bled Steam Temperature, F	178.3	174.9	170.5	166.7	161.7	159.6	131.0	130.2
Water Temperature Entering, F	86.6	82.9	85.2	77.6	83.9	74.1	80.0	70.3
Water Temperature Leaving, F	173.3	171.0	165.5	163.8	156.7	157.4	126.0	129.6
Terminal Difference, F	5.0	3.9	5.0	3.8	5.0	1.9	5.0	1.2

*The design data assume operation with reciprocating dry vacuum pump and with heater-drain pump on 10th stage heater at all loads.

Actual operation was with steam jet air ejectors, and heater-drain pump was shut down on lowest load.

Operating performance figures have not been corrected to standard throttle and exhaust conditions.

**Maximum design flow.

***In design figures the water flow through 4th and 7th-stage heaters equals throttle flow whereas the flow through the 10th and 13th-stage heaters is less than throttle flow by the amount of drains returned to feed line by heater-drain pump. In the operating figures there are deviations from this schedule because of variations in condenser hotwell level.

water is transferred through the condensate storage system. Excess condensate in the low-pressure system goes into the storage tanks while the deficiency in the high-pressure system flows from the storage tanks through the low-level chronometer valve and spray pipe into the main condenser from which it is pumped by the 75,000-kw unit pumps into the high-pressure boilers.

Metering equipment provided for the booster-pump operator's guidance, in addition to pressure gages, consists of flow meters to show the steam flow to the superposed turbine and feedwater flow to the booster-pump suction. These instruments are pictured in Fig. 89. The pump speed is regulated to keep these two flows approximately equal. Net pumpage is less than indicated on the flow meter by the amount of the pump packing leak-off which flows back to the suctions of the low-pressure system feed pumps. Any small inequalities of this nature between the amount of steam used by the superposed turbine and the amount of feedwater pumped back to the high-pressure boilers are rectified automatically by the transfer of condensate through the storage system.

Performance of the Feedwater Heaters and Pumps

The importance of satisfactory operation of the feedwater heaters and boiler-feed pumps cannot be stressed too much, since good performance of the heaters is essential to plant economy while unfailing service of the pumps is essential to plant safety.

Thermal performance of the feedwater heaters has been excellent, the terminal temperature differences satisfying the specifications on all heaters. Even with low initial throttle temperature, the desuperheat zones in the 4th and 7th-stage heaters have performed substantially as specified. Table XVII presents a comparison of design data and operating performance observed during the first two months of service.

The venting arrangement of the heaters described in Power Plant Engineering for September is one factor contributing to good heater performance. It has been found possible to restrict the vent lines to a fraction of their full capacity without impairing the heater operation. Small orifices have been installed, therefore, in the vent lines to prevent cascading an unnecessary amount of steam from heater to heater. It is thought inadvisable merely from the standpoint of mechanical strength to reduce the size of the vent piping itself.

Several annoying tube failures have occurred in the 4th and 7th-stage heaters although this trouble seems to have abated, at least for the present. The design originally called for ¾ in. OD, 11 gage Admiralty tubes for these two heaters. When the units were built, the tube-wall thickness was increased to 10 gage to provide additional safety on the basis of direct stress at pump shut-off pressure. The direct stress at normal working pressure is then about 3000 psi. Irrespective of this low direct stress it has been necessary to replace six split tubes in the 4th-stage heater and three in the 7th-stage heater. Unfortunately it is impossible at this time to report the

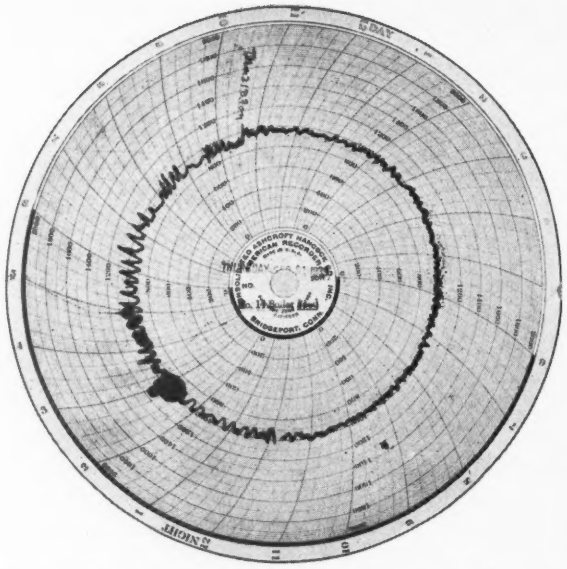


Fig. 90. Boiler feed pressure chart showing reduction in magnitude of pressure fluctuations when booster feed pump is operated in parallel with 75,000-kw unit feed pump

cause of the trouble. Various theories are under consideration concerning it, and of these, a stress theory based on conditions which *might* have arisen during the process of rolling the tubes into the tube sheets seems to offer the best explanation. It would be unfair to state this theory in detail, however, without going into the other phases of the problem in similar fashion, which would not be justified at the present. This experience provides an outstanding example of cooperation among the interested parties. Heater manufacturer, tube company metallurgists, plant operators, and Detroit Edison engineers are all seeking the cause of the failures so that future trouble of this kind can be avoided. In the meanwhile the interval between failures is increasing and there is evidence to believe there may be no more trouble with these units. In this connection it should be mentioned that the use of self-locking heads is of real value in speeding up the repair work although it still is a job of considerable magnitude to open up a large high-pressure heater for tube replacement.

Boiler-Feed Pumps

The boiler-feed pumps function essentially as expected although some adjustments were necessary in their drives. After about four months of service an accumulation of dirt caused a flashover at the brush arm insulation of the slip-ring motor. The pump was shut down immediately and the steam-driven pump put into service. Following this shut down the motor was cleaned, of course, and at the same time the slip rings, which had worn excessively, were resurfaced and new brushes installed. Soon afterward two brushes with lubricative properties were added to each set. Slip-ring wear was thus minimized and no further work has been required on the motor drives. The speed control has proved satisfactory from the standpoint of feeding the boiler, although the sudden bump in pressure which occurs with a speed change has figured in the discussions on the failure of heater tubes. Also there are unavoidable fluctuations in boiler-feed pressure initiated by continuously varying plant load. Both of these effects will be reduced in magnitude when additional units are put into service. Pressure charts taken with the booster feed pump running in parallel with the 75,000-kw unit pump show the steadying influence of the two units upon each other as illustrated in Fig. 90.

The control valve originally furnished with the turbine of the steam-driven pump did not function properly because of excessive unbalanced pressure. A new valve of different design was installed and operates satisfactorily. In the one instance, which followed the valve change, when it was necessary to use the steam pump because of the flashover on the motor driven unit the pump turbine started without hesitation and was delivering water before any perceptible change could take place in the boiler water level.

Heater-Drain Pump

The heater-drain pump is, as stated in the September article, the first constant-speed pump to be used in this service by The Detroit Edison Co., and for this reason it has been watched with considerable interest. To review the pumping arrangement briefly, the heater-drain pump normally takes its suction from the 10th-stage feedwater heater and discharges the accumulated condensate from the 4th, 7th, and 10th-stage heaters into the suction of the boiler-feed pump. Drains from the evaporator and 13th-stage heater always pass to the main condenser. The purpose of this arrangement is to insure deaeration of all drains which might contain dissolved oxygen and other gases either because of infiltration into the heater shell or, in the case of the evaporator, because of the dissolved gas brought into the system with the raw make-up water. On their way to the condenser these drains pass through a heat exchanger where a part of the heat available in them is transferred to the main condensate stream.

At loads above 35,000 kw the steam pressure in the 10th-stage heater shell will be above atmospheric. Most of the operation of the 75,000-kw unit will be above that load so that very little air could possibly enter the system at the 10th-stage. At loads below 35,000 kw the 10th-stage heater is under vacuum and to permit operation of the heater-drain pump at lighter loads the piping was installed as shown in Fig. 91 so that the pump suction can be cut over from the 10th-stage heater to the 7th-stage heater. Under this condition the 10th-stage heater drains pass to the 13th-stage heater shell, though the drain cooler, and into the main condenser.

This set up was one of the first to give trouble when the high-pressure unit went into operation. Without warning the pump would lose its prime, followed by flooding of the heater hot-wells and blowing of high-water alarms. Further, it usually was necessary to shut the pump down before it could be re-primed. This difficulty was liable to occur at any time, although load changes on the main unit were almost sure to

bring it about. Venting of the pump was checked and re-checked. Finally it was found necessary to regulate the pump discharge by throttling to keep a positive head of water in the suction line, maintaining about a half gage glass of water in the 10th-stage heater hotwell. This completely reversed the original intention of allowing the pump to regulate itself through natural variation of static head in the suction pipe and was not, therefore, a satisfactory solution of the difficulty.

In the misbehavior of the pump there was some evidence to indicate that a check valve in the horizontal run of suction pipe at the heater hotwell might be causing the trouble. For example at times of reduction in turbine load the pressure in the 10th-stage heater shell naturally would fall, permitting some flashing in the pump suction pipe with possibly enough back flow of vapor to close the check valve. At the same time the vent line from the pump suction to the heater shell could not handle flash vapor fast enough to equalize the heater pressure and pump-suction pressure, and before a sufficient head of water could accumulate in the heater hotwell to open the check valve the pump would lose its prime. At any rate, the swinging disc was removed from the valve and the pump since has operated properly at all loads above 35,000 kw. When the load is such that the 10th-stage heater is under vacuum the heater-drain pump still is liable to lose its prime, but, of course, it was not intended to be operated under vacuum conditions.

Evaporator Produces Pure Make-Up

At this writing no tests have been made to determine the capacity of the evaporator. However, in connection with certain feedwater studies, samples of the evaporator vapor have been condensed and analyzed. Results of recent analyses are as follows:

Analysis of Raw Water and of Condensed Evaporator Vapor

	Raw Water	Evaporator Vapor
PH value	7.7	5.8
CO_2, ppm.		15
NH_3, ppm.	0.20	0.20
Sp conductance, micro-mho per cm.	190	0.7

The corresponding analysis of boiler feedwater shows the effectiveness of deaeration of low-pressure heater drains and evaporator drains in the main condenser.

Analysis of Boiler Feedwater

Ph value = 8.3	Carbon dioxide, ppm = 0.0
Ammonia, ppm = 0.09	Dissolved oxygen, cc/L = 0.00

The scale shedding feature of the evaporator appears to work well since no appreciable let down in capacity can be noted in normal operation. Scale usually is cracked off three times a day.

Float-operated Drainers

There have been two interesting and contradictory experiences with float-operated drainers in the new section of the plant; one on the evaporator and the other on the 4th-stage feedwater heater.

During the early operation of the new unit the drainer on the evaporator was found to be too small. Examination revealed that the drainer valve had been fitted with an orifice on the discharge side. The orifice was enlarged, with no particular improvement in operation, and finally was removed altogether, after which the drainer capacity was adequate.

In the case of the drainer on the 4th-stage heater the capacity appeared to be sufficient, but at high turbine loads the valve seemed to lock in whatever position it might have had when the high load came on. Action of the float was not powerful enough to open the valve further. Very often the heater hotwell became flooded, causing the high-water alarm to sound, upon which the operator would open the by-pass around the drainer and allow the unit to operate in that manner until the load was reduced.

Various remedies for the trouble were considered, including additional venting of the drainer float chamber. The valve was dismantled, and found to be free from any sticking or binding. Finally it was reasoned that although the valve is of the balanced type it actually became unbalanced at the high pressure differences across it which accompany high turbine loads. This analysis suggested the installation of an orifice at the discharge of the valve so that a part of the pressure difference would be taken across the orifice and leave a more nearly balanced condition for the valve. Accordingly a simple plate orifice was installed at the drainer outlet. The drainer now operates freely except at the extreme limits of its travel, and this occurs only when the valve is moved manually. In its normal operating range there is no binding and the drainer functions automatically at all loads and through load changes to handle all the drains from the 4th-stage heater. It is believed that use of a somewhat smaller orifice might eliminate the binding which occurs even at the limits of the valve travel, but there appears to be no reason to change the orifice merely to accomplish that end.

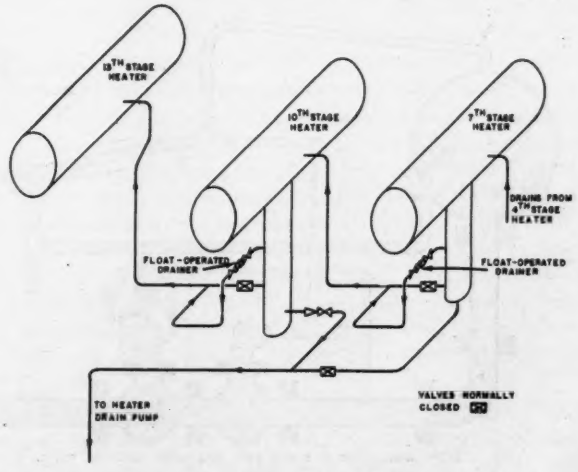


Fig. 91. Diagram of drain piping installed on 7th and 10th stage heaters of 75,000-kw turbine

TABLE XVIII. TEST PERFORMANCE OF 53,620 SQ FT CONDENSER
75,000-KW UNIT 14

Steam to condenser, lb per hr	449,000	387,400	253,300	153,600
Enthalpy of steam, Btu per lb	983.4	970.0	947.4	957.2
Cooling water used, GPM	70,400	49,600	55,000	57,200
Cooling water temperature entering, F.	40.6	37.6	39.7	38.6
Cooling water temperature leaving, F.	52.6	52.2	48.2	43.7
Total head across circulating pump, ft.	15.7	10.0	12.3	12.0
Power input to circulating pump motor, kw.	342	130	178	190
Exhaust pressure at condenser inlet, in. Hg	0.712	0.655	0.487	0.358
Pressure at condenser hotwell, in. Hg	0.677	0.635	0.475	0.351
Pressure drop through tube bundle, in. Hg	0.035	0.020	0.012	0.007
Saturation temperature at condenser inlet, F.	69.0	66.5	58.1	49.6
Temperature of condensate in hotwell, F.	66.4	64.7	56.0	48.7
Undercooling, F.	2.6	1.8	2.1	0.9
Calculated Heat-transfer rate, Btu/hr sq ft F.	365	327	321	329
Air removed by steam-jet ejectors, Std. CFM at 29.92 in. Hg and 32 F.	2.31	1.78	2.01	1.86

Feedwater Regulators

Feedwater regulators installed ten years ago with the low-pressure boilers are of the single element, level-actuated type. It was found necessary, in practice, to adjust the actuating mechanism between high and low boiler ratings because of the wide change in pressure drop across the regulating valve over the complete range of flow.

In the discussion of feed pumps and drives given in the preceding installment it was pointed out that with an inter-connected system of boilers it is necessary to carry the boiler feed pressure at a value that will supply water to whichever boiler is steaming at the highest rating. This, in turn, means that the feed pressure is higher than required for boilers steaming at lower evaporation rates, with a corresponding excess of pressure drop across their feedwater regulating devices.

Because of the older Delray experience the feedwater regulators installed at Conners Creek and in the Delray Extension are of the two-element type shown schematically in Fig. 92. The second element is actuated by water level in the boiler drum as before, and is preceded in the feed line by an element which is controlled by the pressure drop across the second element. In other words, the regulator consists of two valves in series, the first of which operates to give a constant pressure drop across the second while it, in turn, is controlled by the water level. Pressure drop across the first valve varies automatically as needed to match the existing conditions of boiler feed pressure and boiler steaming rate.

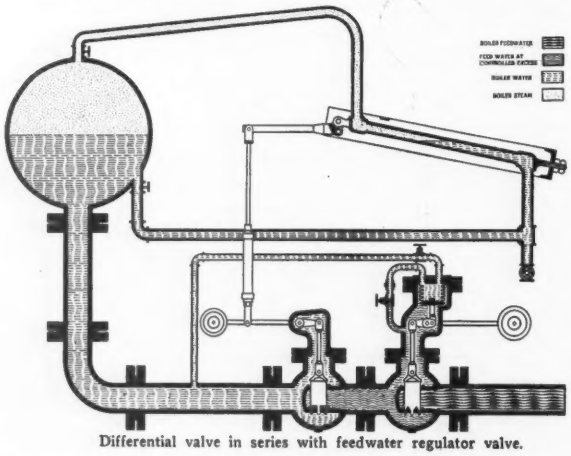


Fig. 92. Schematic arrangement of feedwater regulating valves for Delray 865 psi boilers

Just how this system of feedwater regulation functions was well demonstrated during the first days of operation with the high-pressure boilers. The regulators had not received their final adjustment, and it happened that the first element, or excess pressure regulator, was set for a somewhat smaller capacity than the level valve. As the boiler steaming rate was increased the water in the boiler drums fell to lower and lower levels. The water tender called upon the pump operator to furnish more water, but when the pump speed was increased there was an increase in feed pressure but no increase in the flow rate. It became necessary to open the by-pass around the automatic feed valves in order to maintain the desired level in the drums. What happened was, of course, that the pressure regulating element functioned just as intended. Greater excess pressures from the feed pump caused the regulator to squeeze down more and more to maintain a constant pressure drop across the level-controlled valve. When the required adjustment of the pressure regulating valve had been made the system behaved in a normal manner.

Performance of Main Condenser and its Auxiliaries

Operation of the 75,000-kw main condenser has been watched with considerable interest by Detroit Edison engineers since it is the first new condenser that has been bought for ten years. It possesses not only the advantages of modern welded construction but also incorporated in its design are the refinements and technical advancements that have been found worth while from years of experience with older units.

Performance data given in Table XVIII above are taken from the results of extensive tests made on the new condenser during December, 1938. The tests were conducted to obtain data on this particular unit for use in determining how best to operate it and for use in designing future condensers.

From the above data it may be concluded that the condenser is giving excellent winter-time performance. Data for summer-time operation have been obtained but are not yet available for publication. As a result of the tests there are, however, a few refinements that have been suggested for future condensers of this size.

Quite apart from the condenser performance it was found that the power input to the circulating pump motor fluctuated unduly, causing excessive sparking at the commutator. The first step in correcting this condition consisted in shifting the pump impeller axially about 1/16 in. Another factor causing the power fluctuation was found to be a wave motion set up in the intake canal by a concrete projection on the side of the canal near the circulating pump intake. The projection was partially removed and the power fluctuation is much reduced, though not yet completely eliminated.

Use of a rubber-seated butterfly valve in the circulating pump discharge has not been an unqualified success. As first constructed, the rubber seat ring was cemented in place but would tear out when the valve was opened. The revised design, in which the seat ring is held in place by metal clamps has overcome that difficulty, but the valve does not shut off as completely as desired and some further refinements are contemplated.

The steam-jet air removal equipment performs in a satisfactory manner. When the unit first started the steam nozzles of the ejector became plugged with scale from the inside of the piping. After the nozzles were thoroughly cleaned there was no further trouble. Each of the turbine-driven d-c machines and older main units is equipped with a reciprocating dry vacuum pump which may be connected to a header. Whenever one of the older units is not running its reciprocating vacuum pump can be, and usually is, used for priming the condenser to start the 75,000-kw machine. The priming ejector, or evacuator, which has been used on occasion performs as expected, but consumes so much steam that it is more economical to use a reciprocating pump for priming whenever it is feasible to do so.

Two problems arose in connection with the operation of the high-level chronometer valve which admits condensate to the storage tanks at times of increasing turbine load. It was found that condensate was being pumped to storage continuously as a result of damage to the valve seat caused by tramp material inside the pipe. This experience, together with the plugging of the ejector nozzles, emphasizes the need for extreme care in cleaning all kinds of foreign material from the inside of power plant piping. The second problem did not involve the chronometer valve itself, but had to do with the pressure control valve installed between the hotwell-pump discharge and the chronometer valve to prevent flashing in the pump discharge line when the chronometer valve opens. At times of high water in the condenser hotwell the chronometer valve failed to pass the required amount of condensate because the pressure control valve closed off too much. A pilot operated regulating valve was then substituted for the original valve and the system has performed since without adjustment.

Delray Plant

Performance of Steam Generating Equipment

OPERATING problems with the new steam generating equipment may be divided into two main groups; those arising from the accumulation of ash on heat transfer surfaces, and stoker difficulties arising from the use of wet stock coal in the winter time. It was the better part of judgment, of course, to recognize the possible need for making alterations in the equipment and to build the units in such a way that any necessary changes could be made. Such provisions have served their purpose well as will be described presently.

Design of the steam generating equipment was discussed at some length in the May issue of POWER PLANT ENGINEERING. In describing the boiler circulation system it was stated that preliminary tests indicated circulation ratios well above the design value. Additional experience substantiates the findings of the preliminary tests that circulation is ample for safe continuous operation at maximum rating.

Before the first new boiler was put into operation it was believed that whenever the boiler was brought into service it would be necessary to adjust dampers so that combustion gases would all flow through the by-pass to prevent damaging the superheater. Tests and experience have shown that this procedure is not required and that the unit can be handled normally because sufficient steam is generated during starting to keep the superheater cool. This fact is of importance to some of the changes now being made.

During these first months of operation a number of alterations have been made in the steam-generating equipment, so that none of the operating data at present available can be considered representative. Steam temperature at the superheater outlet now can be maintained at the design value over a wide range of load and for prolonged periods of time. Temperatures of stack gas and preheated air, on the other hand, vary materially with the condition of the heat transfer surface and often exceed the design values by 20 to 30 degrees.

Present shortcomings of the steam-generating unit are explained as follows: The system of integral soot blowers, described in the May installment, which had worked out so well at Conners Creek, does not clean

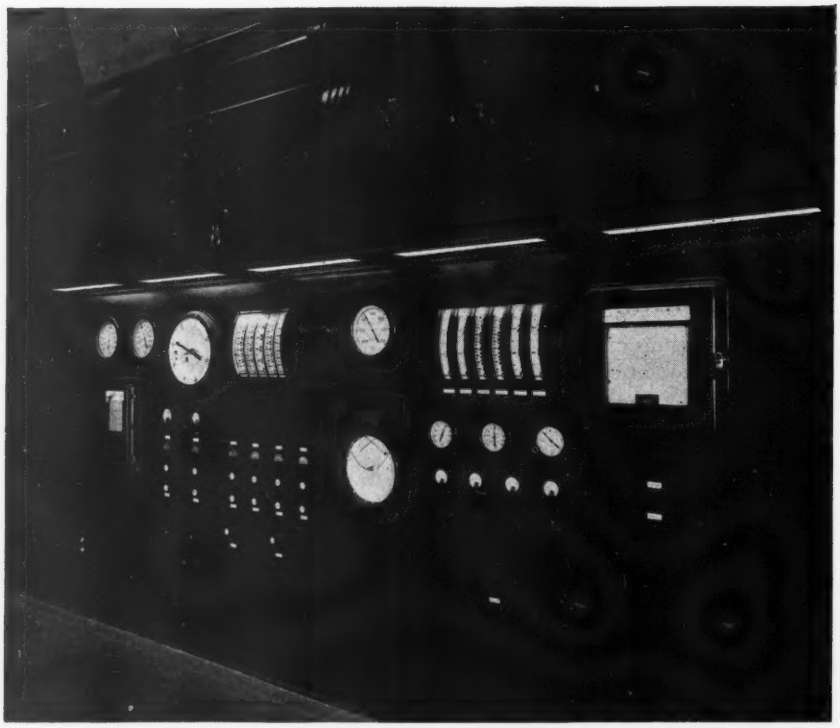


Fig. 93. Operating instruments and control board for one of the 865 psi boilers

the entire superheater surface adequately because of the depth of the superheater tube banks and close spacing of the tubes. Changes have been made in the soot blowing system which doubled the amount of steam used, and additional telescopic, or retractible, blowers have been installed. It appears that the superheater tube spacing, 2½-in. tubes on 3.3-in. centers, is too close from the standpoint of cleaning. Because the heat transfer rate in the superheater is less than assumed in design, it is necessary to pass a a larger portion of gas across the superheaters to keep the final steam temperature at the desired value. As a result the middle section of the economizer is by-passed to a greater extent than contemplated in the design and the consequent laning of gas possibly has some effect even in the air heater. This condition reduces the total heat transfer in the economizer and results in stack temperatures and preheated air temperature higher than expected. A high stack temperature is, of course, a direct loss of overall efficiency whereas a high preheated air temperature may contribute to stoker difficulties, extra maintenance cost, and loss of availability of the equipment. During the first few months of operation, which began December 1, 1938, these conditions were aggravated by improper combustion of the fuel and the by-passing of gas around the bottom end of the superheater. Efforts to improve the stoker operation proceeded collaterally with the changes made to improve heat transfer.

Changes to Improve Heat Transfer

The problem of obtaining better heat transfer in the superheater has been attacked from two somewhat inter-dependent points of view. It has been tried on the one hand to obtain better control of the gas going through the superheater by means of baffles while efforts also have been made to keep the surface cleaner. Any arrangement of baffles which interfered with cleaning would not be acceptable. As shown in Fig. 27 of the May installment the unit was built originally without any superheater baffles.

Three different experimental arrangements of temporary baffles were installed to learn whether an appreciable portion of the combustion gases had been by-passed around the lower end of the superheater loops in the earlier operation. These can best be understood by reference to Fig. 94.

The first set of baffles, shown at the bottom of the figure, were made entirely of baffle tile 2 in. thick laid in place on metal supports while the low wall between the superheater and rear boiler bank was made of firebrick laid up dry except for a few courses top and bottom which were bonded to hold the wall together. An immediate improvement in superheat and gas temperatures resulted from these baffles. However, a large amount of refuse collected in the pockets which they formed, the horizontal tile between the front and rear superheater banks being especially bad.

As a second step the horizontal tile between superheater banks was removed. This prevented the accumulations of ash between superheater banks but the remaining baffles were not completely effective in preventing the combustion gases from by-passing superheater surface. The third step attempted to reduce the by-passing around the front superheater bank to a minimum, and to improve the sealing arrangement

between the superheater and rear boiler bank. The middle sketch in Fig. 94 shows how this was accomplished using cast nickel alloy plates. Further improvement in superheat was noted, but the pockets had not been eliminated although cleaning the rear superheater bank after a shut down was facilitated by replacing the brick wall with a metal plate.

The three trial baffle designs led finally to a permanent design, shown in the upper drawing of Fig. 94, which has been adopted for the three high-pressure boilers now installed. These baffles effectively prevent by-passing and at the same time do not form pockets. There still is some accumulation of refuse on the front-bank baffle, but judiciously placed soot blower nozzles clean the rear-bank baffle while still others blow refuse from the top of the boiler mud drum over into the economizer soot hopper. It is believed that the superheater is now baffled in a way that provides as complete control of the gas flow through it as can be achieved.

Three major steps have been taken to increase the effectiveness of soot blowing, as follows:

1. Changed from saturated to superheated steam for soot blowing
2. Increased soot-blower nozzle area to pass twice the original amount of steam
3. Installed telescopic soot blowers between the front and rear superheater banks.

The properties of steam are such that when saturated steam at boiler pressure was supplied to the soot blowers, the combined effects of pressure drop and increased kinetic energy resulted in steam leaving the soot-blower nozzles in a wet condition which seemed to "plaster" refuse on the tubes. By changing to superheated steam and using nozzles designed for the new conditions the steam now blows with a final superheat of about 120 F. At the same time the new nozzles were built to pass twice as much steam as the original ones since a more vigorous blow evidently was needed.

These changes were of benefit in two ways. Not only was the final superheated steam temperature increased but it was possible to keep the steam generator on the line for longer periods of time without shutting it down for hand cleaning. However, because of some irregularity and the closeness of tube spacing even the improved soot blowers have been unable to keep ahead of the dirt and it has been necessary, at intervals, to resort to hand lancing. As of October 1 it has been possible to keep a boiler on the line continuously for six or seven weeks without a serious increase in draft loss.

Telescopic soot blowers supplied with saturated steam at 200 psi g have been installed recently to minimize the amount of manual cleaning.

Another important change to improve the overall heat transfer in the steam generator has just been made as this is written. This change involves relocating the superheater by-pass dampers on one boiler. The original position of the by-pass dampers at the economizer outlet was discussed in POWER PLANT ENGINEERING for May, while the present article already has indicated that the superheater problem together with the by-pass damper location is responsible for reduced effectiveness of the economizer heat transfer surface. Fortunately, it is possible to bring up the boiler in the same way as a normal boiler and there is no necessity for passing all the furnace gas through the by-pass when starting up. Since it has never been found necessary to damper the superheater sections to force gas

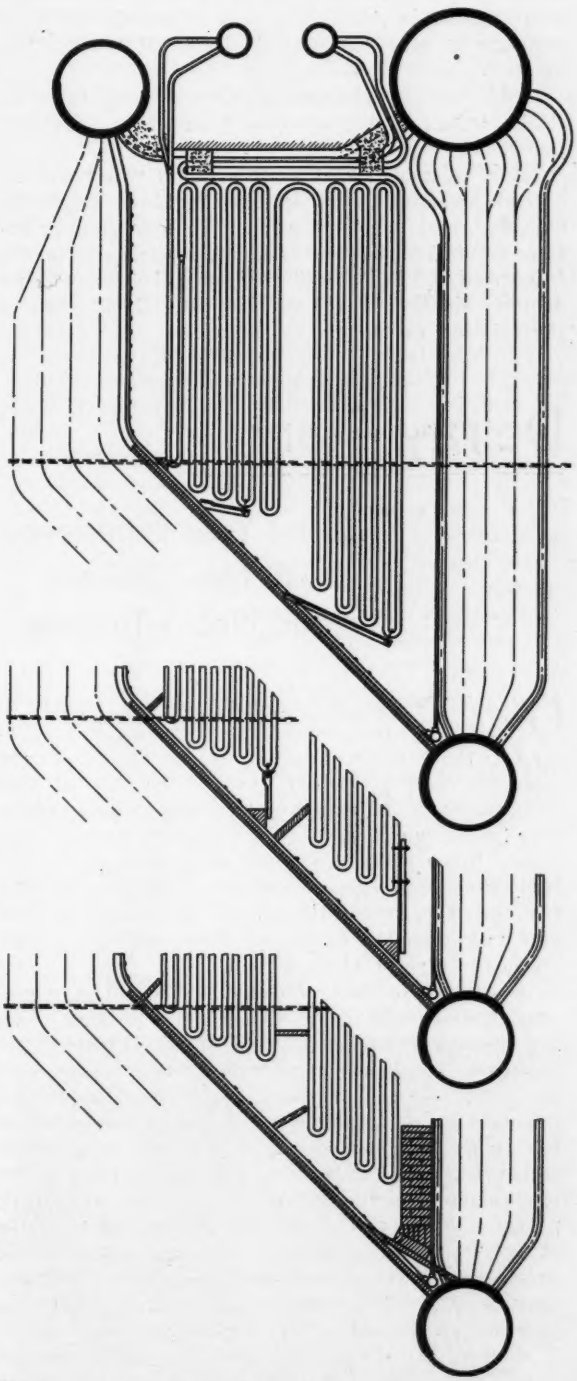


Fig. 94. Baffle arrangements tried out in the 865 psi 900 deg F superheaters. Lower and center arrangements were experimental. Final design is shown in the upper drawing

through the by-pass, it is believed feasible to move the by-pass damper to the boiler outlet. By removing the by-pass partitions between boiler outlet and economizer the entire surface of both the economizer and air heater will become active, irrespective of the by-pass damper opening. The new damper design covers only the by-pass section while the superheater sections themselves will be left without dampers. The by-pass section of the rear boiler bank also is being baffled to increase the heat transfer in that circuit and reduce the gas temperature as much as possible before it reaches the damper.

Additional soot blowers also are being installed in the lower half of the economizer to effect greater cleanliness.

It is calculated that these changes will result in overall performance at least as good as originally expected, and initial runs with the new damper arrangement indicate that the anticipated effects are fully achieved. The two remaining boilers will be changed similarly if the one just altered continues to perform satisfactorily.

Delray Plant

First Year Experience with New Stokers and Noblo Tuyeres

OPERATING experience with the new stokers at Delray has been especially interesting in view of the fact that similar units were in operation there for some ten years previously. One of the older stokers had been equipped with Noblo tuyeres to gain experience for guidance in initiating operation with the new units. Since many conditions other than tuyere design influence stoker performance it is not surprising that the experience with the older boiler did not provide a complete and final guide for operating the stokers in the high-pressure section.

In the new furnace a fuel bed that would have been considered normal in the 400 lb boiler produced long lazy flames, which passed into the superheaters and deposited ash on them. Furnace temperatures were low, superheat was low, and as previously mentioned the stack temperature and preheated air temperatures were high. The fuel bed built up at the fronts of the stokers in the two boilers then installed, causing failure of the power-box shearing pins on one unit while pusher failures and severe burning occurred in the other. It is believed that the high temperature of the preheated air was at least partly responsible for these failures since coke formations indicating excessive temperature were found in the retort bottoms.

Following this experience the stokers were operated with lighter fuel beds which shortened the flames somewhat and lessened the rate of sponge ash accumulation in the superheater. The beveled ram faces also were machined to vertical since there was some thought that the beveled rams were a factor in causing the fuel beds to build up at the stoker front. Subsequent operation showed there was no appreciable improvement in fuel bed conditions with the vertical ram faces and that in some cases there were coal formations on the rams which interfered with the coal feed. Beveled faces were again installed. Adjustment of the pusher strokes retarded the rate at which the fuel beds would build up, but if the strokes were not increased soon enough the fuel tunneled out in the retort, leaving heavy masses bridged across the tuyeres. Meanwhile, air and steam lancing were being performed on the superheater to improve the steam temperature and reduce the preheated air temperature.

It must be remembered that these first months of operation were during the winter when wet coal from stock was being used. There seemed to be no doubt that the excessive moisture contributed in large measure to the difficulties that were being experienced. Stock coal constituted the available supply, however, and it was necessary to operate with it.

Difficulties with uneven distribution and heavy fuel beds at the stoker fronts continued to occur. Clinker formations at the front wall had to be barred off with water-cooled bars. It was decided to carry somewhat heavier fuel beds to protect the stoker and reduce the burning of iron, such as shown in Fig. 95, and in an effort to reduce the fuel bed at the stoker front the beveled ram faces were turned 180 degrees from their normal position. These later were turned back to their original positions.

Some of the shedding plates in the plenum chamber were removed because it was thought they might be causing poor air distribution to the tuyeres, but these later were re-installed and some air deflecting baffles put in as illustrated in Fig. 96 to direct the air upward at the stoker front. Twenty static-pressure tips installed in one of the plenum chambers four feet above the shedding plates showed uniform air-pressure distribution under the stoker.

Near the end of March the pusher strokes were adjusted to produce tighter packing of coal in the retorts. The result was imperfect combustion as indicated by the presence of CO and excessive smoke. The

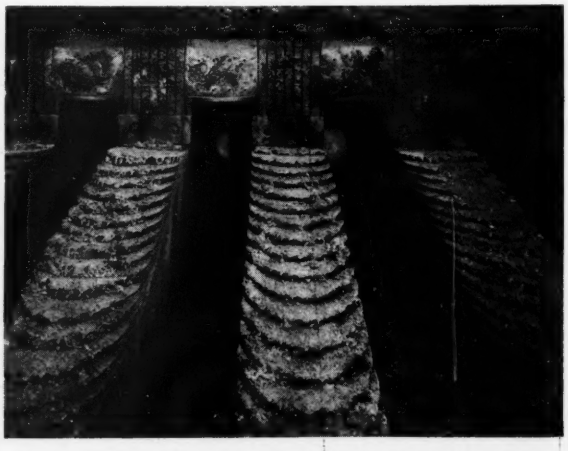


Fig. 95. Example of tuyere burning encountered with wet coal supply

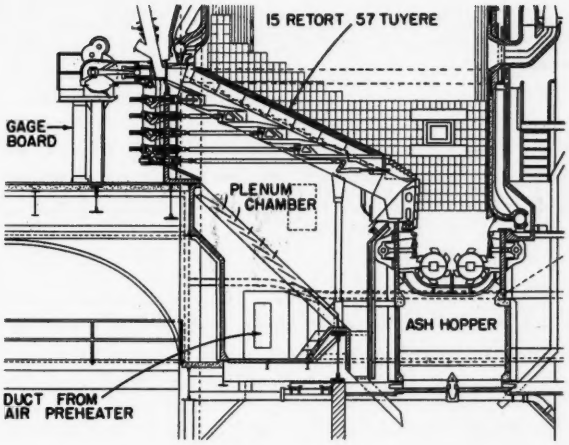


Fig. 96. Drawing of stoker and plenum chamber showing altered arrangement of shedding plates with air deflectors installed

pusher strokes were then altered again to produce only moderate packing. About that time the coal supply became somewhat drier and stoker operation began to improve.

Heavy deposits of sponge ash illustrated in Fig. 97 continued to form on the superheater tubes, however, emphasizing the need for shorter flames and better cleaning of the superheater. While the Noblo tuyeres offer more resistance to air flow than do normal tuyeres, it was decided to increase the tuyere resistance still further to make the burning lanes more pronounced. Accordingly the air passages on each side of each tuyere plate were partially plugged and plenum chamber pressures were increased to compensate for the added resistance. The fuel burned with shorter, more blasty flames, but the burning lanes were not improved appreciably.

Thermocouples installed in the tuyere support plates were of some assistance in operating the stoker since they showed when combustion began to extend down into the retorts.

By the first of June a steady supply of cargo coal became available and combustion conditions and stoker operation improved to a point where the evaporation rate could be stepped up to 330,000 lb per hr per boiler. It is worthy of mention that stoker troubles have practically disappeared except for days when damp stock coal is used. To combat the winter-time troubles resulting from wet coal a trial installation of an agitator in the stoker hopper as described in the second article of the series is to be put in on one unit this fall. Several schemes for partially drying the coal in winter time also are under consideration.

Mechanical refinements in the stoker design have all been satisfactory. Of special value is the method of supporting the stoker on pin-ended struts. This feature has eliminated the sagging encountered with the older units and has thereby prevented binding of moving parts which most likely would otherwise have occurred when the retorts were overheated.

To sum up, boiler performance has been improved considerably during the past year, but the ultimate solutions have not been reached either in the matter of cleanliness and heat transfer rate in the superheater, or in the satisfactory feeding of the wet coal used during winter months.

Conclusion

This final installment of the series is largely a recital of difficulties. It has been made so intentionally in the belief that a frank statement of the weaknesses that have been uncovered will be of greater general value to those who may read these articles than would a long discourse on the many items in plant operation that have been successful. In all cases where no mention is made of either satisfaction or difficulty it may be assumed that operation is substantially in accordance with expectations.

Operating records are not kept separately for the two sections of the plant owing to the difficulty of segregating the amounts of coal used in the two sets of boilers. Based on what is known from past performance of the low-pressure section, however, it appears that the new equipment is delivering energy at a heat rate which satisfies the expectations for the plant. With improved cleaning of the steam generator heating surfaces and with corrected feeding of coal during the winter months it is probable that some further reduction in fuel consumption per kw-hr will result.

General satisfaction with the new plant is attested by the fact that similar equipment is contemplated for additional units in the plant extension. Such alterations and adjustments as have been required in the first high-pressure unit will, of course, be incorporated in the initial building of the second set of apparatus. In the case of the superheaters for new boilers a wider tube spacing will be used to facilitate cleaning. On the whole, however, the same fundamental designs can be used throughout the extension.

In conclusion the author wishes to acknowledge the cooperation and helpfulness of his many associates in the engineering, design, construction, and operating departments of The Detroit Edison Co. Their suggestions form the real basis of the Delray story as it has been told in these articles. Reviews of the manuscript by Mr. P. W. Thompson, Chief Engineer of Power Plants and engineer in charge of the extension project, and by Mr. J. W. Parker, Vice President and Chief Engineer of the Company, have added immeasurably to the authenticity of the series, and have otherwise been most helpful.

Fig. 97. Views showing accumulations of "sponge" ash in the front section of the 865 psi 900 deg F superheater

Simplification— Mr. Keeth Prognosticates

By J. A. KEETH

Manager of Power Production
Kansas City Power & Light Co.
Kansas City, Mo.

This article, prepared from what was originally a letter, was buried in the files for 7 yr. and can almost be called "The lost manuscript." It has a long, and the Editors feel, an interesting, history which warrants some mention.

1930 may be placed as the end of a definite and memorable era of power plant progress. Reheat was well established for large stations and smaller station design was fairly well standardized. With no immediate prospect of bettering thermal efficiencies, the thoughts of the industry were turned to reducing investments as the most logical method of lowering power generating costs. "The Simplified Plant" was as common a term as "The High Temperature Plant" is today although somewhat more idealistic than real.

It was something to look forward to—an ideal built around a single boiler and turbine stripped of all non-essentials in order to reduce cost. In an effort to define "The Simplified Plant" the editors carried on an extensive correspondence with prominent engineers and manufacturers including practically all members of the Prime Movers Committee of the N. E. L. A. as it then existed.

Today history is repeating itself. While the full possibilities of high temperatures have not been exhausted there is sufficient operating experience to indicate that many of the refinements and complications thought necessary for high temperatures are playing no really vital role. There is again an insistent demand for simplification, a demand which will undoubtedly be met as operating experience indicates where trimmings can be cropped off. More critical operating conditions and larger sizes of units indicate that automatic control will play an increasingly important role in the future but with the controls confined to individual functions and coordinated through the process of power generation.

In an effort to find how the present movement for simplification paralleled that of an earlier day the old 1932 file on Simplification was dug up. Mr. Keeth's letter dated September 27, 1932, seemed as applicable today as it was 7 yr. ago and is reproduced here with little alteration beyond change of tense from future to past in several sentences, and some minor alterations explained in a recent letter quoted in part below:

"I am not entirely satisfied with the remarks made regarding turbine supervisory instruments because I believe that a number of those mentioned are refinements which can well be dispensed with.

"You will note that I have deleted the comments regarding the binary vapor cycles with particular reference to the mercury turbine. This type of equipment seems to be pretty well on the shelf at the present time.

"Again I have not followed your suggestion in offering comments on automatic boiler control for the reason that at the present time I have no definite opinion to express. In years gone by I was personally opposed to automatic combustion control, feeling that the cost of the equipment far outweighed the advantages obtained from it. There have, however, in the past few years been very material reductions in the cost of this type of equipment. As a result, when we installed our new boiler unit in 1937 we made our first installation of automatic combustion control.

"Its cost was not excessive and the results obtained were so promising that we later equipped one of our old high pressure boilers with similar type of control. Both units are giving excellent accounts of themselves and we have had little difficulty keeping the automatic control in almost constant use. I would not care, however, to express myself as being either for or against it until we have had a little more experience. I am sure that it is not saving us any labor and I doubt very much if it is greatly improving our operating economy. On the other hand, it does relieve the boiler operator of certain responsibilities which leaves his mind more free to take care of other things not automatically controlled in case of trouble."

REDUCTION of power plant construction costs seems to involve three major considerations, namely, less frills, less duplication of equipment and the use of simpler heat cycles. A more or less comprehensive discussion of each of these follows:

Frills refers chiefly to those architectural features which add only to the asthetic point of view and in no way contribute to the plant from a utilitarian aspect. From 1925 to 1929 the great majority of the plants were built apparently to stand as monuments to a flourishing industry. The buildings had the appearance of public structures, many with beautifully parked grounds about them. Terra cotta or cut stone has been plentifully used as was ornate tile walls and floors. In many places, structural steel has been covered with paneled plate work, serving no other purpose than improved appearance. Plants constructed during the war of necessity contained little or none of these trimmings, nor is it probable that plants now building or to be built in the immediate future will contain any of the purely ornamental.

The matter of less duplication of equipment possibly has more bearing on the cost of the plant than any other one item and is probably subject to more discussion pro and con than any other feature in design. In the past, particularly in the metropolitan areas, it has been the practice to duplicate nearly all of the major equipment such as condensate pumps, boiler feed pumps, circulating pumps, certain piping, exciters, switches, etc. In most cases entire boiler units were duplicated for reserve. However, desire to reduce construction costs is developing an increasing tendency toward less duplication. Justification of this attitude is found in the ever increasing reliability of plant equipment. Improvements in water treatment and a better knowledge of boiler chemistry seem to have increased the service availability of boiler units until it is on a par or even better than the turbine and condenser; hence, today we find numerous new installations of turbines with but a single boiler serving each. Chlorination of circulating water has practically eliminated condenser cleaning.

The single boiler unit for each turbine seems to be a major step in the lowering of plant construction costs. Not only is a saving made in the purchase of boiler capacity in larger units, but also in the installation and piping costs. Usually considerably less building space is required by the single large boiler than by the equivalent capacity in smaller units. Improved dependability of stokers or pulverizing equipment and elimination of practically all furnace maintenance by the use of water-cooled walls and arches have permitted uninterrupted operation of boiler units for many months at a time. The numerous factors

which have all contributed toward this improved use factor have all played their part in cost reduction.

There is still much discussion as to duplication of certain pumps but there is a decided trend toward less duplication where the continuous operation of any pump is not absolutely essential to the continued operation of turbine or boiler unit as a whole. Failure of some particular equipment may result in uneconomical operation or even somewhat reduced load operation during the time the repair is being made, but this can usually be tolerated, especially on a large system where considerable flexibility exists and is economically better than a large investment in duplicate equipment which stands idle most of the time. A typical example of this type of equipment might be heater drain pumps. In case of failure of this unit, extraction might be cut or the condensation returned to the hotwell through a loop during such time as repairs are being made. Duplication of circulating pumps can and frequently is avoided, particularly where cross connections can be obtained.

Another practice that may gain some favor, if it has not already done so, is that of increasing plant peak turbine capacity by cutting off all or part of turbine extraction during these peak periods. Feedwater temperature may be sacrificed during these peak periods if the boiler plant capacity is sufficient or hot water can be stored to carry through these periods of peak load. It will be seen that such a scheme involves a balancing on the part of the designer or generator, boiler unit and water storage tank costs to determine whether it will result in an actual saving in any specific case. Duration and frequency of peaks are vital factors in such studies.

Continued development of supervisory turbine control instruments by both large turbine manufacturers should result in a reduction of certain turbine room construction costs. A single operating floor at the elevation of the condenser floor will adequately serve the entire turbine unit. Such a plan not only eliminates turbine room floor and possibly intermediate floor constructions but should save operating labor and afford better daylight illumination for the condenser elevation. In this plan turbines would be mounted on the usual foundation with nothing but inspection balconies at the customary turbine floor level. Throttle valve as well as all drain valve controls are brought down to the condenser floor level.

A turbine supervisory switchboard would be provided on this floor which would contain instruments for indicating and recording vibration amplitude, expansion of spindle or other parts, eccentricity, interference, speed, and other instruments such as gages and thermometers would be provided. It seems probable that this type of construction may gain favor as a means toward building simplification and more economical operation. Already several so-called outdoor stations have been constructed and are in operation. In these cases, the boiler is usually out of doors with a structure to house only the turbine, switchboard and a certain amount of the electrical equipment along with the complete boiler control board. Such construction, where climatic conditions permit, bids fair to lower building costs.

The electrical part of the power stations offers possibilities of taking its part in reduction of plant construction costs. A few years ago phase isolation was popular in the larger stations. Such construction was generally expensive and has not proved as effective a safeguard to service as anticipated. Today the more conventional type of bus and switch construction is returning to use but bus protective equipment is being generally installed at probably a considerable saving over phase isolation with or without its accompanying protective relay equipment. It would seem probable that certain auxiliary feeds could be grouped without sacrificing plant dependability. A single feed for each boiler forced and induced draft fan might under certain conditions be an example of this. In many cases the failure of either the forced or induced draft fan on a boiler unit is sufficient either to seriously reduce its capacity or to entirely shut the unit down. Therefore, there appears little justification for complete separation of these two feeds. There are probably many other instances where additional grouping would be practical.

Heat Cycles

Simplification of plant heat cycles is a most interesting one, particularly because of its intimate relation to such economic factors as cost of fuel, cost or quantity of water available and cost and proficiency of the operating force available. During the period of the great growth of utilities from 1925 to 1929, apparently all effort was concentrated upon the building of plants to operate on more and more efficient cycles and this to the at least partial exclusion of the cost point of view. Money for expansion and new construction was easy to obtain, hence, there was little reluctance toward adoption of expensive heat cycles. However, the industry was extremely fortunate in having such a condition, as development was undoubtedly advanced many years thereby. The extensive development of higher pressure during this period has brought the cost of that type of equipment down to the point where it is actually competitive with the more conservative pressure of the past. It is believed also that performance of this equipment has demonstrated conclusively its dependabilities.

In most cases reheat cycles have added considerably to construction costs and developments during the last few years in the use of higher temperatures have largely eliminated the need or economic value of reheating with the higher pressures. A premium must be paid for high temperature equipment but it is not improbable that more extensive use of such equipment and a better knowledge of the characteristics of materials at high temperatures will lower this cost so as to result in a considerable net saving over the use of lower temperatures with reheat.

For the experienced power plant designing engineer, we do not believe the day is far distant when he will be turning out complete, dependable and efficient plants at a cost of from $65 to $75 per kw. Such costs can, however, only be obtained where the demands of the distribution system connected to the plant do not require such a multiplicity of low capacity feeders and duplication of plant switching facilities as has frequently been the case in the past. The constantly increasing labor costs are, however, tending to absorb a fair share of the savings due to design.

What is a Watt?

By
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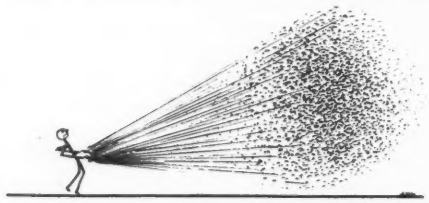
Research Department,
Lamp Division,
Westinghouse Elec. & Mfg. Co.

WE OFTEN talk of watts, kilowatts, and horsepower, without really having any clear idea of what they are. We know vaguely they are measures of the strength of machines, or the strength of natural forces. But we do not know how big the machine is, or how powerful a natural force is described by "one watt", "one kilowatt" or forty horsepower".

How many know that the strength of a small kitten is 1 watt, that of a man is 150 watts, or that a busy, buzzing bee, sturdily winging his way across a garden, would have to get the help of nearly a million of his fellows to equal the pulling power of one man? On the other hand, an automobile has the power of nearly 500 men!

Different kinds of power cost different amounts. Electricity is one of the cheaper kinds, for a power of one watt usually costs but one cent for 200 hr. use. Radioactive energy is one of the most expensive kinds.



One million bees pulling a man

One watt of the energy of radium would require 33 grams, a little more than an ounce, worth about $50,000,000 and a substantial fraction of the entire world's supply of 25 ounces. If we should buy one cent's worth of this kind of energy we would be allowed to use the one watt for but an infinitesimal fraction of a second.

Sound has energy, and as on a busy street the babel of noise assails us from every side it seems to have a very great deal of energy indeed. Yet, if we could cut out and set aside a cube of air on a noisy street, and measure the sound energy is contained, we would find that if the cube measured five feet on each edge it would contain but one watt of sound energy. This is very different from the same volume of highly heated steam and water in a steam boiler, which may contain many thousands of watts of potential energy in another form, heat.

150 kittens = 1 man

The energy of light is small. A light which appears brilliant to our eyes has very few watts in it. The light given out by an ordinary 25 watt incandescent lamp, for instance, is just about one watt, as far as its effect on our human eyes is concerned. The sun at its brightest, however, can place 1/3 watt of "light-power" on every square inch of the earth's surface which it strikes.

Light starts striking chemical reactions. One so common we don't think about it is the action of light on photographic film. This, too, can be measured in watts. The reaction is so sensitive that as many as 10,000 sq. ft. of film can be turned jet black by exposure to one watt of light for only one second.

Ultraviolet rays, or "blacklight" can also be measured in watts. The well-known sterilamp used for killing bacteria, for instance, emits 1.2 watts of pure bactericidal rays (2537 A.U.). This most effective ray will kill bacteria very rapidly. Although more efficient that the usual incandescent lamp, the sterilamp, still by no means converts all of its electrical imput into the wanted germ-killing rays.

Our efforts at producing and transforming energies from one type to another deal with rather small energy values in comparison to the total amount of material originally used. For example we use tons of coal or fuel oil to heat a small home during the winter; 250 lb. of water must flow thru the turbines at Niagara Falls to furnish enough power to toast one slice of bread. If we once learned the secret of tapping subatomic energies, very small amounts of material would suffice to supply all our needs for artificial power. The complete annihilation of matter give off unbelievable amounts of energy. A container the size of a golf ball filled with hydrogen gas at atmospheric pressure possesses enough pent up energy to heat our average size house all year. The potential energy of one ounce of alpha particles (the subatomic

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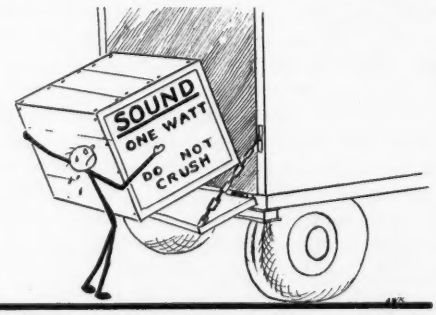
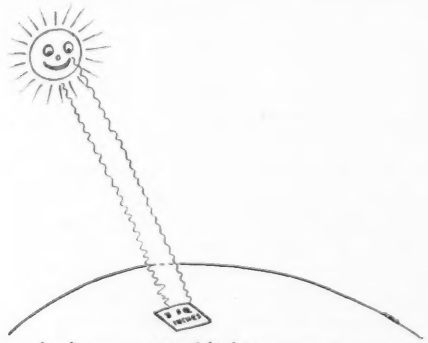


One cube of air 5 ft. on edge contains one watt of sound



Bright sun sheds one watt of light power on every 3 square inches of the earth

Detailed cost comparison of two popular forms of power presented before the North Carolina Ice Association, Inc., convention shows that the net difference in cost per ton is given closely by comparing Diesel fuel and lubricating cost with purchased power cost

ICE COSTS— Diesel vs. Electric Power

By
H. E. GRAHAM
Fairbanks Morse & Co.

POWER EXPENSE as an item in the total production cost of ice is of major importance to all ice manufacturers. Many plants today are making ice by means of electric power, a number are using Diesel power and a comparative few are still making use of steam power plants. Uppermost in the minds of those using purchased electric power are such questions as: How much would my power costs be reduced if I used Diesel power? How much would a Diesel installation cost in my plant? Are Diesel engines a dependable source of power? How much trouble will they give me to keep them in running order? Why should a Diesel engine make power cheaper than I can buy power from a large utility whose business is the manufacture and sale of power only? Am I liable to experience expensive shutdowns during the height of the ice season? What are the means of utilizing Diesel power in my particular plant?

Obviously, we must talk in more or less general terms of comparison since we propose to compare electric power costs with Diesel power costs and neither one of these is known definitely at this moment without making reference to a specific plant. There are, possibly, no two plants whose power costs are identical to the cent per ton. Likewise, there probably are no two plants represented here today in which Diesel power would show exactly the same cost per ton. These costs vary with the head and suction pressures under which the plants operate, with the type of machinery used, the method of drive from the source of power, with the personnel in charge of the operations and with the bookkeeping methods as well. Electric power rates also vary and, in the case of the Diesel powered plant, the cost of fuel oil varies and is higher as the plant location is more remote from the coastal ports.

Cost Items

It would be well to consider all items entering into power cost, any and all items which could possibly be thought of as part of the total power cost. In the case of Diesel power, we believe that these items consist of the following: Fuel oil; lubrication oil; labor or attendance; maintenance; taxes; depreciation; interest on the investment; insurance; and incidental expenses covering purchase of wiping rags, gasoline, etc., for cleaning purposes, or any other small items which may be necessary to operation of the plant.

In comparison, electric power costs consist of the power bill, instead of fuel and lubricating oil costs, and the other items as enumerated for Diesel power. All of those charges could be made against any plant, although the book records may not take all of them into account. We propose to discuss the amounts of the various charges in comparing the total cost of Diesel power with the total cost of electric power, but for the moment we will assume that either power cost may be divided into two parts,—the power bill and overhead expenses.

Assumed Plant Conditions

For our purpose we will assume that our plant data shows the following: Ammonia compressor, 8 by 8 in. operating at 360 r.p.m.; average summer pressure, 205 lb. head and 20 lb. suction; 225 lb. head and 20 lb. suction, maximum pressures; winter pressures, 145 lb. head and 25 lb. suction; horsepower in plant auxiliaries, 20 hp.; annual production, 5850 t. or approximately 22 t. per day; electric power cost, 95 ct. per t. We further assume that Diesel fuel oil will cost 6 ct .per gal. delivered in carload or tank car lots that lubricating oil of the proper grade costs 40 ct. per gal. at the location of this particular plant. The plant is so arranged that a Diesel engine may be directly connected to the ammonia compressor and a generator may be belt driven from the engine shaft for the purpose of supplying the auxiliary power required.

Calculations indicate that the maximum horse-

power requirement or maximum demand under hottest summer conditions is 95 hp., the total output required from the Diesel engine to drive the compressor and auxiliaries and provide for some losses. The average summer requirement for this plant would be 91 hp. For winter operation the horsepower requirement would be 80 hp. We must, of course, provide an engine large enough to handle the maximum requirements of 95 hp. and operate at the speed of 360 r.p.m. of the compressor. In this instance, my particular company would recommend a 120 hp., 360 r.p.m., two cycle engine. We can assume that the total expenditure necessary to install Diesel equipment will be approximately $8000 and proceed to determine the Diesel power cost for this plant.

Based on the manufacturers guarantees, and without going into details of the calculations, for 180 days of summer operation and 90 days of winter operation, the fuel and lubricating oil costs, Diesel "power cost or The Diesel power bill", will total $2,015.50. As the plant produces 5850 t. annually the average Diesel power bill will amount to 35 ct. per t. The comparison of "power bills" is then*,

Electric "power bill" per ton.....95 cents

Diesel "power bill" per ton.....34.5 cents

This is not the whole story, however, as we haven't yet added the "overhead expenses" for either type of power and we are interested in the total cost of power per ton of ice.

Overhead Costs

Consider each of the items of overhead expense. First on the list is the operating personnel under labor or attendance. Each plant owner will endeavor to secure an operator who is thoroughly dependable and an experienced mechanic of ordinary intelligence. The installation of a Diesel engine will not be cause for the employment of additional or more high-priced help and the charges for the operating personnel will, therefore, be the same whether Diesel power or electric power is used. Hence, the labor cost involved may be disregarded in determining power cost or it must be considered as much a part of the cost of electric power as for Diesel power. We will consider it a part of the power cost in this instance and assume that this charge amounts to $2,000.00 per year.

The second item is Maintenance in which is included repair costs. Surely, there is some expense in maintenance of the electric motors. However, we will assume that no maintenance or repairs are required in the electric plant although it should be borne in mind that the cost of any such repairs or maintenance is properly a charge against electric power as much as repairs to a Diesel engine could be charges against Diesel power costs.

What about Diesel maintenance? Volumes of evidence are available on this subject and I might say that by picking individual plants as examples Diesel maintenance can be proved to be enormous or practically nothing. Records which my company has available, however, on more than 2000 units shows that maintenance on two cycle engines, over 100 hp. in size, costs approximately 76 ct. per hp. per year over the life of the engine. This covers all sizes over 100 hp. and takes into account all major as well as minor repairs.

We say that, conservatively, maintenance should not exceed $1.00 per hp. per year for two cycle engines. For four cycle engines, the accepted conservative figure is $2.00 per hp. per year, somewhat higher than for two cycle engines because of the necessity of continued adjustments to obtain most economical operation. Since we are assuming the engine in this case to be two cycle, the maintenance charge will be made at $1.00 per hp., or $120.00 per year for the 120 hp. engine. Obviously, the charge is more than sufficient in the early years of the engines life for the maintenance during the first 5 yr. should be negligible.

Taxes and Depreciation

Taxes are ever present and must be considered, however, the addition of a Diesel engine is rarely a cause for increase in the assessment for taxes. Conservatively again, we will assume that the tax assessment is increased and that taxes must be charged against Diesel power but not against electric power. We refer, of course, only to the increase in taxes. We will take this charge at 1 per cent on the investment or $80.00 per year.

Our next item is depreciation about which volumes have been written. In spite of these volumes there seems to be as many ideas on depreciation as there are people interested in the subject and one individual may have several methods of determining depreciation, depending upon the reason for which he makes the determination. Far be it from the speaker to pose as an authority on this subject. However, we will sidestep—after a fashion—and approach this item in a manner such that we might have general agreement on the figures used. We will assume that this particular addition to the plant is made by making a down payment of $2,000.00 and the $6,000.00 balance is to be paid monthly over a period of three years.

As a matter of bookkeeping we may then follow this reasoning: The addition requires an actual expenditure of $2,000.00—the balance is considered as rent paid monthly for the use of the equipment over a 3 yr. period, at the expiration of which title is cleared and rental payments stop. We are interested —under this plan—only in recovery of our $2,000.00 over the period of the useful life of the equipment. We, therefore, make an annual charge for depreciation or amortization in order to recover our investment. Or, we set up a sinking fund, the annual deposit on which shall be an amount which when left on

*Editor's Note: At this point the analysis data is incomplete in several particulars: 1, Annual kw-hr. required under assumed conditions; 2, Consumption of fuel oil; 3, Cost of fuel oil per gal.; 4, Consumption of lubricating oil; 5, Cost of lubricating oil per gal.; 6, Cost of power per kw-hr. Using the data given earlier for summer and winter operation, approximately 566,000 hp. hr. would be required. Assuming 90 per cent efficiency in both cases, this would mean about 630,000 hp. hr. generated by the engine and 630,000 × 0.743 = 468,000 kw-hr. purchased. The total purchased power bill would be 95 × 5850 = $5556.50, giving an assumed power cost of about 1.19 ct. per kw-hr.

Assuming 3000 engine hp. hr. per gal., approximately 179 gal. of lubricating oil would be required annually which, at a cost of 40 ct. per gal., would cost about $71.50. Assuming 0.5 lb. per hp. hr. consumption of fuel oil running 7.3 lb. per gal. and costing 4.5 ct. per gal., some 43,200 gal. per yr. would be required at a total cost of $1944. This, plus the lubricating oil cost of $71.50, would give the total operating cost of $2015.50. It should not be assumed that these are the exact figures used by Mr. Graham but they are consistent and sufficiently close for the purpose in hand.

Another point not mentioned by Mr. Graham is the time required for overhaul and inspection of the single engine, a period during which the plant cannot be operated. The assumed operation of but 270 days a year does, however, allow ample time for this without interfering with regular operation as assumed.

deposit with annual compound interest added will amount to $2,000.00 when the time arrives to replace the engine.

We must, of course, determine the expected useful life of the equipment and the interest rate at which our money is to be deposited to set up the proper amount. If the useful life of the engine equipment is considered to be 20 yr. and interest accumulates at 6 per cent per year either on the deposit of the money or use of it in the business, then the rate for depreciation or amortization is 2.72 per cent. The percentage figure will, of course, vary as the term of years is varied and as the interest rate used is increased or lowered. We have evidence to indicate that 20 yr. is a reasonable life expectancy for an engine and each individual knows in his mind the rate at which he may earn returns on his investments or deposits. At 2.72 per cent our annual deposit for reserve or depreciation is $54.40, at which figure we will charge this item against Diesel power. Bear in mind still that some depreciation is also chargeable against electric power but in this instance, we are not making that charge in order that our comparison may be the more conservative. Wouldn't it be reasonable to assume that the figure we have determined is "the difference" in depreciation under the two plans regardless of the period of time or interest rate involved?

Interest on Investment

Interest on the investment is the next item for attention and an item which may be considered from various viewpoints. We believe that you will agree that interest is the return made by an investment. Or, in this instance, we should properly omit interest as a part of the power cost and calculate the "saving" in power cost as compared to that cost under use of purchased power and then consider the difference as the return on the investment. Do you charge interest against your payments of purchased power bills? The purchase of power is an investment but usually you forget about that in your bookkeeping and determine your profits without taking such an item into consideration. We believe, therefore, that interest on the investment should be excluded from any power cost comparison—or, if included, interest should also be included as an item of electric power cost. In the interest of a conservative comparison, however, we will exclude interest on the electric power bills but include this item in the total cost of Diesel power. Since 6 per cent is considered the usual rate for interest and the actual sum invested is $2,000.00, the annual charge for interest would be $120.00. This amount will be included as a part of Diesel power cost.

What about our next item—Insurance? You already provide for insurance on your plant. That cost includes insurance on your motors. Isn't it true, therefore, that part of your insurance premium should be charged against purchased electric power costs? Consequently, only the difference in premium caused by the installation of Diesel equipment should be charged to Diesel power, or such a charge should be made for either purchased electric power or Diesel power. Again giving purchased electric power the advantage of the doubt, we will consider insurance on the Diesel equipment as a part of the Diesel power cost. We believe that 1 per cent on the purchase price should be more than ample and will, therefore, set a charge of $80.00 per year for this item.

Incidental expenses are an item of cost. How much of your incidental expense do you charge against your power cost? I believe you will agree that you make no such charge for the reason that the charge is so small as to be negligible. This statement is just as accurate when applied to a Diesel powered plant. Such things as wiping rags, kerosene, gasoline, light bulbs, etc., are incidental to either the electric motor or Diesel engine plant. We can only select an arbitrary figure in this instance and will include a charge of $5.00 per month or $60.00 per year for both types of plants.

Cost Summary

Recapitulating we find the charges against electric power and Diesel power to be the following:

	Electric Power	Diesel Power
Power Bill (Oil for Diesel)	$5,557.50	$2,015.50
Labor	2,000.00	2,000.00
Maintenance or Repairs	0.00	120.00
Taxes	0.00	80.00
Depreciation	0.00	54.40
Interest	0.00	120.00
Insurance	0.00	80.00
Incidentals	60.00	60.00
TOTAL Power Cost	$7,617.50	$4,529.90

It is quite apparent from this comparison that Diesel power would be advantageous for this particular plant because of the "saving" of more than $3,000.00 per year on a conservative estimate. This means a power cost per ton of ice amounting to about 77.5 ct. for Diesel power as compared to $1.30 for electric power or a difference of some 52.5 ct. per t. in favor of Diesel power. Of course, this saving is not all net profit for during the first 3 yr. of Diesel use $2,000.00 per year is used to pay for the equipment.

We stated earlier that the power cost comparison without the "overhead" expenses was about 95 ct. for electric power and about 34.5 ct. per t. for Diesel power. This is a difference of 59.5 ct. per t. as compared with a difference of 52.5 ct. per t. in total power cost. The deduction should be as follows: If all items of cost are considered, the saving by using Diesel power is approximately the difference between the cost of fuel and lubricating oil for the Diesel and the total of the monthly power bills. Don't permit the issue to become complicated with discussions of depreciation, maintenance, labor costs, repair bills, etc.—those have all been taken into account in our present comparison.

What is a Watt?

Continued from Page 712

projectiles given off by Radium) is equivalent to the energy contained in 250 freight cars filled with small bore rifle bullets. Thus in comparison with nature's ability to transform matter into useful energy, our best efforts are very feeble.

So we see that ultraviolet rays, visible light, sound, heat, electricity and mechanical energy can all be measured in watts. By these simple illustrations the equivalence of different forms of power is made clearer. Different as are the effects of the various kinds of power they are all forms of the same general thing, and each can be turned into any of the others.

Combustion Control Specifications

Part V. Different manufacturers accomplish results in different ways so good specifications should outline what the control system is expected to accomplish but avoid telling how it is to be done.

By
RICHARD H. MORRIS
Engineering Editor

REGARDLESS of the equipment involved, specifications should be definite and concise, worded so as to allow free competition while insuring proposals based on comparable equipment. For automatic combustion controls, the specification writer must know, and make clear to the manufacturer: the extent of automatic control and what it is intended to accomplish; the equipment which is to be controlled; and conditions or terms under which equipment will be purchased, or special conditions about the plant which might have a bearing on the design.

To a large extent, the details of a given make of control system will depend upon the make and type of boiler auxiliaries which have been selected and which must be controlled. It is, therefore, necessary to include, in the drawings or text of the specifications, information and data to enable the control manufacturer to visualize the plant and to determine, from the specifications, his own files or from other manufacturers, just how a control is to be applied to each damper, valve or part to be moved. While it is better to have too much rather than too little information of this kind, the data in which the control manufacturer is vitally interested are rather limited and are explained in greater detail later.

General features of the control system, not fixed by the equipment involved, must be determined by the manufacturer from the specifications. These must include the general requirements as to type of system, what it is to accomplish and how flexible it has to be to meet the expected method of operation during the starting and stopping periods as well as during normal operation.

Cost

While personal idiosyncracies and the money available play an important part in deciding these points, the size and arrangement of the boiler, type of load and qualifications of the operating personnel are usually the most important factors, especially if the decision to use automatic control hinges on its economic justification. As a rule few of the advantages of automatic control can be definitely evaluated. One that offers the best chance of evaluation is fuel savings which, in industrial plants, may run as high as 10 per cent and can be conservatively estimated at from 1 to 5 per cent of the fuel burned, depending on the class of labor available, the supervision, the type of load and character of the control system.

The expenditure that can be well justified for control thus depends directly on the size of the boiler, although the cost of a given control is largely independent of boiler size for it is determined to a large extent by the number and type of regulators demanded by the requirements for flexibility and performance. Due to load conditions and the high standard of operation, fuel savings due to automatic control will in general be less in large central stations than in industrial plants. In the former, however, control is necessitated by other factors as mentioned later in connection with large boilers.

Metered and Positioned Control

Metering and positioning are important terms in combustion control literature with emphasis on the former of recent years, especially in connection with larger installations. However, even on large boilers, complete metered control may not be possible because of the auxiliaries or boilers involved. Metered control presupposes that the steam, air and fuel flow can be accurately measured and proportioned to each other automatically. This means a separate regulator for each function so that a metered control involves all the elements needed for flexibility. This may be, but is not necessarily, true of a purely positioned control because flexibility can, if desired, be sacrificed for simplicity.

While air flow can usually be measured with reasonable accuracy on the conventional boiler, measurement of fuel flow, especially with some types of pulverizers and stokers is impossible and accurately calibrated positioned control must be used. On some low draft loss boilers with large water wall surface and little convection heating surface, air measurement may, however, involve more difficulties than the fuel. This is especially true in those units involving a divided gas flow between the economizer and superheater. A reliable air measurement with a sufficient differential to operate instruments is a point

which the designing engineer should not overlook for it is of vital importance to the operators.

Further, the term complete system has little real meaning for a control may be complete as far as design and operating conditions in one plant are concerned but quite incomplete in another. Neither "positioned," "metered" nor "complete" are adequate terms for describing the type of control desired and, until other terms are coined, the type of control can be defined only by telling what it is to do and specifying definite and measurable tolerances of performance.

Small Boilers

Needs of a small boiler, with the auxiliaries convenient for direct operation while the boiler is cut in or out of operation, can usually be met by a simple positioned type control system. For a single boiler this may involve only a steam pressure and a furnace pressure regulator with one of them moving two or more regulating devices in parallel. A characteristic of such a system, from which the name positioned is taken, is that the position of the damper or controlled device bears a definite relation to the position of the regulator. For this reason the different characteristics of the devices involved must be reconciled by calibration devices or cams.

With one regulator responsible for two or more functions, the performance depends largely upon the accurate calibration and consistent characteristics. Provision for manual or automatic adjustment in-

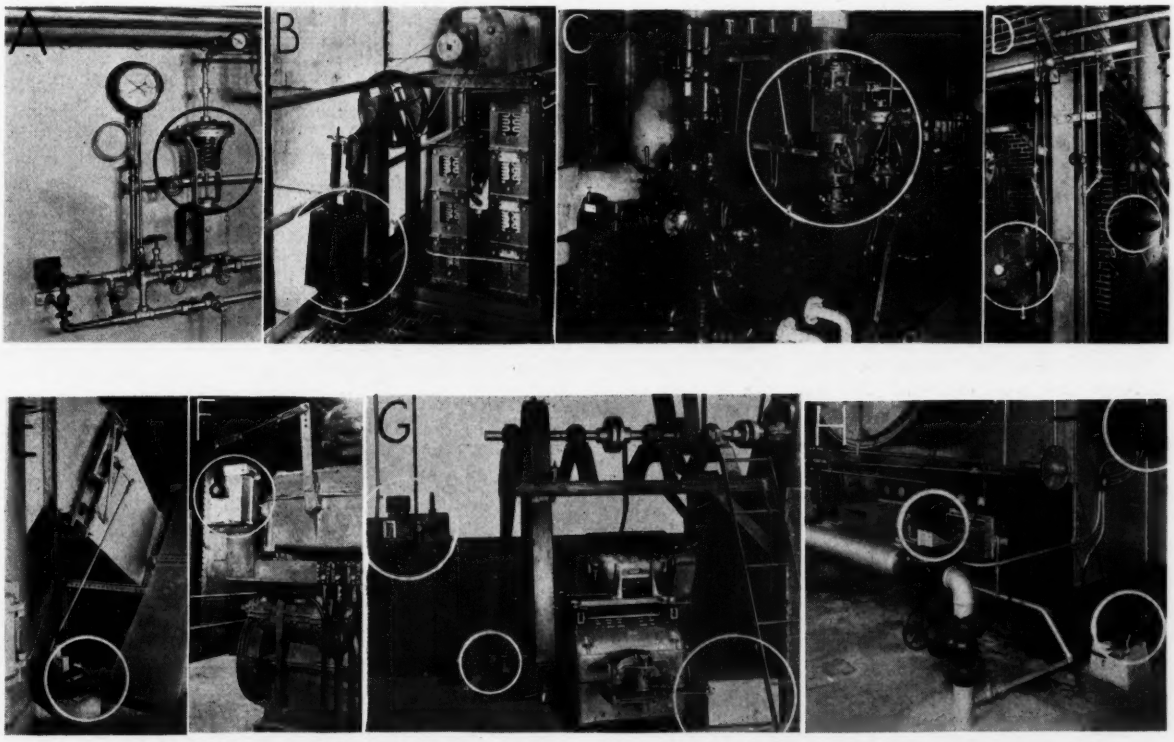


Fig. 6. Installation of combustion control is facilitated if some thought is given by the plant designer to the problem of mounting the regulators and power operating members. Construction practice has not been standardized, some times the regulator and power operating unit are built together and some times they are separated. If separated, the regulator may be mounted on a panel or at any convenient location, but the power operating member must be located where it can be attached by levers, shaft or cable to the part or machine to be moved. If both regulator and operating unit are built together the whole is, of necessity, subject to the same location restrictions as the separate power operating unit. Typical mountings of both types are shown above. Some of these show that the matter of control was given slight consideration when the major equipment was selected and the plant designed

A shows an air operated diaphram valve controlling both the oil valve and steam valve for a steam atomizing oil burner. This particular unit is rigidly supported from the boiler front and acts as an anchor point for the small piping. Diaphram operated valves are, however, commonly installed in the pipe line like any ordinary valve. Diaphram motors are built double or single acting for air or water operation (oil attacks the rubber diaphram) and while more commonly used in connection with valves are sometimes used with a lever arrangement for operating dampers or other devices.

B shows a double acting air operated cylinder (with the regulator built integral) arranged so that the reciprocating motion of the cylinder is transferred to rotary motion to move a drum type motor controller. This particular cylinder is pivoted at the bottom with the frame bolted to the grating.

C shows an oil operated regulator with the operating unit built integral and arranged to control the speed of a multi-nozzle turbine through a governor. The welded channel iron support is fastened rigidly to the turbine base plate.

D shows a steam pressure controller mounted on a column and a furnace pressure regulator mounted on the side of the boiler. The oil operated power cylinders of both units can be located by careful inspection. Both are arranged to operate dampers through a system of levers and shafts.

E shows an electric power operating unit mounted on the floor and arranged to move a multi-bladed induced draft damper.

F shows an electric power operating unit mounted on a rigid structural steel support and arranged to move a mechanical speed changer on a chain grate stoker drive.

G shows an electric power operating unit mounted on the floor and controlling a mechanical speed changer on an underfeed stoker drive. Note the blower tachometer at the end of the shaft and used to give a metered indication of stoker speed. The regulator is built separate from the power operator but is mounted on the wall nearby instead of on a pa' as is more common with the electric controls.

H shows three parts of an electric control on a small gas fired installation. The steam pressure controller is mounted on the boiler wall and columns, the damper operator on the floor with cable connection to a jackshaft, and the fuel operator directly on the gas valve.

creases the cost and tends to automatically remove the control from what has been termed the very simple type. While the fuel savings with a simple positioned system will not run as high as with a complete metered or more elaborate positioned system, the simple system is rugged and reliable and is all that is usually justified on a purely economic basis for boilers up to perhaps 350-450 hp. The equipment cost of a very simple control of this kind for a small boiler may be as low as $500.

Large Boilers

When the boiler is large, however, and the auxiliaries not readily accessible for direct operation, provision must be made for remote operation during starting up periods. The trend here is to centralize these controls at a given point or panel. Furthermore, the quantity of fuel involved makes is advisable to provide convenient manual or automatic adjustment to take care of minor or unexpected variations in fuel or air conditions. To do this easily and conveniently requires a separate regulator for each control point. If several boilers are involved, provision for dividing the load between them, equally or unequally, for making adjustments on one boiler without affecting the others and for setting maximum and minimum load limits is often incorporated.

The cost of a complete automatic control system for a large boiler, including the panel, will run several times the cost of a simple control. To get a true picture of the cost, however, the net cost of automatic control must be taken as the total cost minus the cost of remote control and panel which would otherwise be necessary for manual operation and instrument mounting. When this is done the automatic control cost on a thousand pound per hour basis is negligible. Even without this allowance, the cost of a complete control on a large boiler will, on a thousand pound per hour of steam basis, be only a fraction of the cost of a simple control on a smaller boiler.

Plant Details

Often plant conditions have a significant bearing on the details of control design, especially if new boilers are to work in parallel with old ones, different sizes of boilers are to be used or if the plant is to be extended in the future. Sometimes conditions favor one operating medium, electric power, air, oil, or water, over another. Electric power in a central station is always, and in an industrial plant usually, available but the others may not be. In industrial plants compressed air often is, and if clean, dry and reliable, the control cost can be reduced slightly by eliminating a separate compressor. Oil is a good power transmission medium and also lubricates part of the control but is seldom if ever available around a power plant under sufficient pressure so that an oil operated system must always include an oil pump. Water is not often used due to corrosion and scale difficulties but when a reliable supply of soft, filtered water is available under pressure as in a water works plant it offers a cheap and satisfactory medium for the power operating members.

Drawings and Panels

The specifications should be accompanied by a simple outline drawing showing a cross section of the boiler, furnace and baffle arrangement, location and arrangement of auxiliaries, ducts and dampers. Some times a plan and cross section are sufficient but in many cases additional detailed drawings are necessary. Information on the equipment to be controlled should include name plate data such as the manufacturer's name, type, number and size of each machine. If the manufacturer's name is not well known nationally, the addresss should be added.

When a control and instrument panel is involved its location should be indicated on the drawing. If the available space is restricted, the overall dimensions allowable, particularly the depth, should be given. The panel should be cut and drilled in the shop but as the size, shape and arrangement of the panel depend largely upon the make of control involved, a detailed layout is not practical, until after the control is purchased. The suggested layout must be made by the manufacturer and he in turn cannot proceed without a complete list of the extra instruments and parts which are to be mounted on the panel with the necessary control.

Therefore specific mention should be made of each item with each identified as to make, type and size. When instruments, control valves, push buttons, etc., not ordinarily considered part of the control system are to be purchased with the control, specific mention should be made of each item together with any preference for a particular make. Control and regulating valves should always be provided with a bypass so as to facilitate maintenance without interfering with operation.

General information about the plant should indicate the number and size of boilers, the operating steam pressure and temperature, method of firing, general arrangement and number of fans, pulverizers, stokers, burners, etc., as well as minimum, average and maximum load and rate of change of load. This general description should be followed by the make, type, size and design capacity of each individual auxiliary and the method of drive.

Whether or not details of the drives are necessary depends on the method of operation. Details of constant speed drives for fans, pulverizers, etc., are of no particular interest to the control manufacturer, nor are the details of transmission, gears, belts or direct connection, if the machine is driven at constant speed. The specification should, however, be specific about the general arrangement of such equipment.

Constant Speed Drives

With constant speed operation, control must be exercised through some secondary mechanism such as a damper, valve. Details of the size, shape, construction and bearing design of dampers should be included together with the maximum flow, maximum

pressure differential which may be expected across it and, if possible, the operating torque required. If a full 90 deg. of rotation is prevented by local conditions or construction, the rotational angle should be included. Vanes on fan inlets should be considered the same as dampers. When control is exercised through valves, the valves are often purchased as part of the control because a particular valve may be well adapted to one system and not to another. If this is done full data should be given on the maximum and minimum flows, pressures, temperatures, allowable pressure drop at maximum flow, pipe size and flange drilling.

Variable Speed Drives

When a machine is driven at variable speed from a constant speed motor through a hydraulic or mechanical speed changer, details of the make, type, and size of the speed changer should be included. With speed changers it is particularly important to state how the control force is applied, that is through a pilot motor, lever or a screw adjustment. As a rule the third method is not well adapted for automatic control, not only because it is more difficult to apply but because it is apt to be slower and not stand up well under constant service. With a pilot motor, the control circuit voltage and current characteristics should be given. With the lever type, the length of the lever, stroke, place of operation, arc, plane of travel and, the required thrust for operating should be included.

Variable speed drive details are of vital importance to the control manufacturer. These details cover the make, type, size and speed range whether it be motor, turbine or engine. For motors the same data should be given for the controller or rheostat and, if pilot motor operated driven controllers are used, the current characteristics of the control circuit should be added. Resistors and controllers for large motors are often purchased with, or at the same time as, the motors but small motor rheostats are often purchased with the combustion control for the same reason that valves are. If this is the case it should be stated clearly.

Data on steam drives should be very specific both as to the make, type, size and steam conditions and steam consumption of the drive itself and the method of speed control. If the speed control is to be applied through a governor which is part of the turbine or engine, or, through a throttle valve purchased separate from the control, the make, size and type of governor or valve should be given. If the throttle valve is to be supplied by the contractor as part of the combustion control the data given should also include the desired flange size and drilling. It is also well to include the steam pipe size and length for an excessive pressure drop in the steam line may, quite independent of the control, make proper operation impossible and throw an undue burden of responsibility on the manufacturer.

Combination Controls

When a combination of damper and speed regulation is used complete details should be given, not only of the equipment involved but the expected method of operation. Multispeed motor drives in two or more steps, as well as two separate single speed motors come in this group. Both the speed change and damper movement may be handled automatically or the speed change may be handled manually and the arrangement used in a given case should be made clear.

In the first case, data on the motor and starter as well as on the damper should be given. In the second case, the motor is of importance to the control manufacturer only if a remote means of speed change is brought down to, and incorporated on, the control panel. Remote controls of this kind are usually of the push button type as used for other motors arranged for starting and stopping from the panel and of course involve no direct connection with the combustion control.

If provision for the speed change is to be incorporated in, or supplied with, the combustion control, details of the starter itself must be included. If the push buttons have been purchased, identifying data should be given and to make a good appearance all the buttons on the panel should be of the same type. Electric controls often include switches and push-buttons and for consistancy additional equipment of this kind may be purchased with the control. When special devices such as time relays to take care of momentary voltage dips, or sequence relays to take care of deceleration, is provided on starters or push buttons, or, is to be provided with the control, specific mention should be made for these details may influence the control arrangement.

Power circuits, starter cases and fixtures are usually grounded for safety in accordance with the National Electrical Code but control circuits are usually ungrounded to facilitate locating faults. The practice followed should be mentioned for it may be of importance with certain electrical controls.

When the speed change is left to the operator, the damper controls may be fitted with signals, indicating when the damper is approaching an open or shut position so as to warn the operator that a speed change is needed. A definite statement of whether such a signal device is desired should be included.

While variable speed control alone may be entirely adequate as far as flexibility is concerned, a combination speed and damper control is often desirable for large fans where inertia effects or inherent time lags with some speed changers may cause hunting. Controls can be arranged to handle this combination operation so that the damper is operated for quick control and then gradually comes back to normal position, as the speed changes, in order to reduce throttling losses to the minimum.

Fuel Supply

While the data needed is practically the same for all auxiliaries, the fuel and control arrangement should receive particular attention. Stoker speed must be accurately regulated and provision is frequently made on the control for measuring the stoker speed as an indication of fuel feed. With steam drives, the speed governing mechanism is frequently left for the control manufacturer to supply. In addition to

the drive data, information on the size arrangement and linkage of the dampers incorporated in the windbox construction is necessary if these are to be regulated automatically. With the bin system of pulverized coal firing, the pulverizers are of little interest but data on the feeders and drives and speed controls are necessary. With the unit system of pulverized coal firing complete data on the raw coal feeder and fuel control to the furnace is necessary for the combustion control may be concerned with one or both.

When the raw coal feeders are regulated by a separate control from the fuel level, mill power input, or other means, the general arrangement is sufficient but details of the damper control for the primary air or coal-air mixture are necessary. Mills and feeders have been pretty well standardized and the make, type and size of mill and similar data on the feeder and drive serve as sufficient identification. Some mills are equipped with only one type of feeder but others may be equipped with any one of two or more. The arrangement for fuel control may vary with the same equipment, however, it may involve only the feeder, only a damper in one of several positions, or a combination of both perhaps involving both manual and automatic control. The arrangement used, or to be used, must be stated very specifically.

Changes

Often combustion control specifications are issued before details of the plant and auxiliaries are definitely decided. In this case it is advisable to select the arrangement which will most likely be used as a base to work upon and make definite provisions in the specifications for handling changes that may be necessary in the control if the equipment assumed is not used.

Specifications which follow in Part VI are for a typical medium size industrial plant. These specifications are printed with three different type faces: Roman, bold and italics. The Roman type indicates parts that are more or less general and common to all plants and can be used with little change. Words or sentences in bold face type indicate sections where words, sentences or figures need to be changed to fit specific conditions. Sections or paragraphs in italics indicate portions which are applicable to only the fuel or auxiliary arrangement in the hypothetical plant for which the complete specifications were written.

A number of alternate paragraphs to use with other arrangements follow the complete specifications. The section and paragraph numbering these alternate sections is the same as in the complete specifications. Paragraphs and sections which must be omitted in specifications for a simple positioned control are marked with a double asterisk, **. Tables I and II of the preceding article serve as an index for the alternate sections.

The arrangement followed is simple and is intended primarily to separate in so far as practical the specifications, which are concerned with the necessary data, from the standard or contract parts which are concerned with the problem of avoiding future misunderstandings.

Tables III and IV serve as an index and price summary respectively. Table III revised to meet specific needs may be filled in with the proper page numbers and included at the beginning of the specifications in order to indicate the general arrangement and content and facilitate use. To insure uniformity of proposals extra blanks of Table IV can be included with the specifications, as needed for the number of proposals required with a couple extra for the manufacturer's file copies. A summary of this kind gives a quick comparison of bids, and included as a separate sheet, can be easily removed from copies of the proposals which are to be in more general circulation where the prices are not necessary or advisable.

(To be continued.)

Air Conditioning Conference at Lehigh

AIR CONDITIONING in relation to health, the most practical methods of operating and servicing air conditioning systems, and interesting applications of air conditioning in industry are on the program for discussion at the Eastern Air Conditioning Conference at Lehigh University, Bethlehem, Pa., November 10-11, 1939. Professor B. H. Jennings of Lehigh University is chairman of the Conference Committee.

The First Session will be on Operation and Service of Air Conditioning Systems with A. R. Stevenson, Jr., of the General Electric Co., and past president of A.S.R.E. as chairman. C. C. Williams, President of Lehigh University will greet the conference and the remainder of the session will be devoted to three papers: Refrigeration Storage for Handling Peak Loads, by Carl F. Boester, Consulting Engineer, St. Louis, Mo.; Hotel Guestroom Air Conditioning Practices, by John R. Hertzler, York Ice Machinery Corp., and Analysis of Air Conditioning for an Educational Building, by S. R. Lewis, Consulting Engineer, Chicago, Ill.

At the Second Session on Human Responses to Comfort Air Conditioning Professor Frederick E. Giesecke, of College Station, Texas, and President-elect of the A.S.H.V.E., will preside.

On Saturday morning at the Third Session on Industrial Air Conditioning, Dean A. C. Callen, of Lehigh University, will preside and four papers will be presented: Creating a Demand for Air Conditioning, by J. C. Rosenmiller, Chairman of Advertising and Public Relations Committee, Air Conditioning Manufacturers Association; Moisture Removal from Blast Furnace Air, by L. L. Lewis, Vice President, of the Carrier Corp.; Climate and Air Conditioning, by J. C. Albright, of the Marley Co.; and The Effect of Modified Atmospheres on Cold Storage, by Charles Brooks, Principal Pathologist, Bureau of Plant Industry, Washington, D. C.

Vibration Tolerance

Attempts have been made in the past to establish tolerances for machinery vibration, none of which have been entirely satisfactory or practical for it is not practical to set up arbitrary criteria to serve as a rigid rule for passing or rejecting a given amplitude of vibration for all cases. Vibration may be classified as smooth, rough, destructive and annoying from practical observations, and the conclusions presented in the form of charts. Many factors and reservations which enter into the problem, however, must be made before any such tolerance chart can be used with reasonable assurance. There are two aspects to the general vibration problem:—first, the mechanical, as it affects the safety or maintenance of the machine, and second, the physiological, as it pertains to the comfort of an observer.

By
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Chief Engineer
Turbine and Machinery Div.
The Fidelity & Casualty Co. of N. Y.
Philadelphia, Pa.

LAST EFFORTS to establish a relationship between allowable vibration amplitudes on machines based on their operating speeds have generally been founded on faulty premises. For example, it has been assumed that the intensity or seriousness of vibration depends on the acceleration of the motion rather than directly on the amplitude. Thus, the force with which a rider is "thrown backward" in a car depends on how quickly the car is accelerated from say, zero to ten miles an hour, rather than on the distance traversed.

With simple harmonic motion, like that of the crosshead of an engine with an infinitely long connecting rod, the acceleration varies directly with the amplitude, but with the square of the frequency or the speed causing the vibratory disturbance. Thus, for two equal vibration amplitudes, one at twice the frequency of the other, the acceleration of one is the square of two, or four times the other.

This fact, together with the questioned assumption that the deleterious effect is in direct proportion to the acceleration, has given rise to the so-called "inverse square" rule in attempting to establish vibration tolerances for various speeds. By this rule, if an amplitude of 0.002 in. is permissible for an 1800 r.p.m. machine, then 0.008 in. would be allowed at 900 r.p.m. but only 0.0005 in. at 3600 r.p.m. Such a rule is inconsistent with experience and cannot be applied generally for there are also other factors which prevent rigid comparative values.

Vibration classification may be affected according to the purpose of the criteria. For example, the manufacturer and the purchaser of new equipment are interested in whether the operation comes within what has been vaguely termed "commercial balance," while the insurance underwriter is more vitally concerned with the extent of vibration allowable before the operation becomes hazardous. In this paper, vibration in its relation to possible damage will be the major consideration in attempting to establish tolerances.

Often the problem is concerned more particularly with higher speed machines, such as steam turbine generators and their running balance, but there is no reason why it should be so confined. Professor G. B. Karelitz of Columbia University, while associated with the author on vibration studies at the Westinghouse South Philadelphia Works, tabulated the opinions of several practical engineers and inspectors as to the smoothness or roughness of a number of turbines while on test, operating mostly at 1800 r.p.m., and correlated this data with simultaneous vibration records made with the vibrometer. To this has been added considerable data obtained by the author and his present associates in their machinery inspection activities on all classes of apparatus. The whole has been digested and averaged to arrive at a tabulation of amplitudes in the various categories of smooth, fair, rough, and dangerous, etc., throughout a wide speed range. The resulting data is used by the turbine engineers of the Fidelity & Casualty Co. merely as a guide in their inspection activities.

Measuring Instruments

Instruments for measuring machinery vibration are now fairly common. They are generally of the seismometer type, and customarily are applied at the bearings. The majority of vibrometers measure one component of the motion, such as the vertical, lateral (transverse) or axial (longitudinal). The Davey photographic vibrometer indicates and records the

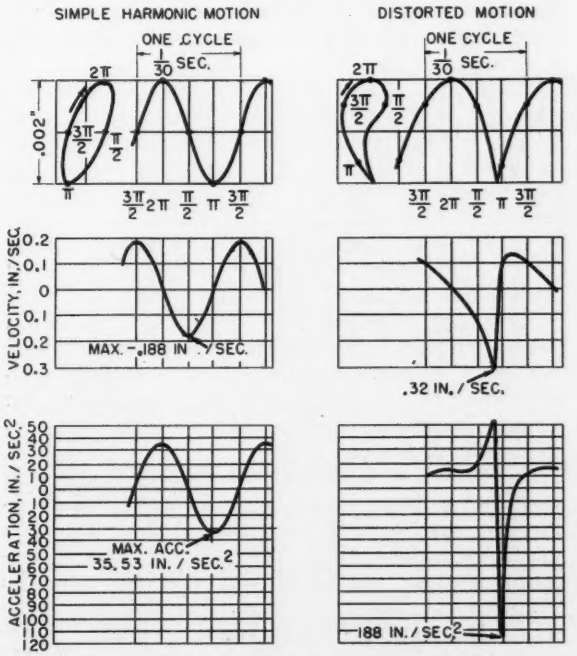

Fig. 1. Comparison of relative vibration intensity between a simple harmonic motion and a distorted motion of the same amplitude and frequency

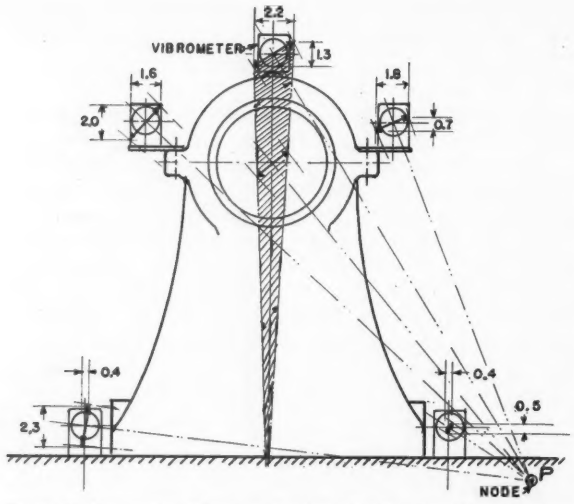

Fig. 2. Turbine pedestal bearing showing why the vibration on the two sides may not be equal

actual path of vibratory motion in a vertical plane, either transverse or axial, so that both vertical and horizontal components are directly observed as the shape or path of the resultant motion. Electric type vibrometers indicate vibration velocity, calibrated in terms of amplitude for given speeds.

If the vibration is simple harmonic at a common frequency, the figure is some form of the ellipse. The figures are often distorted, however, by the presence of two or more frequencies, or by impactive forces such as pounding at the bearing keys, loose wheels, coupling or gear disturances, etc. A common figure due usually to impact resembles a mutton chop. Acceleration is no longer proportional to displacement with such distorted motion. This is why two vibrations with the same amplitude and frequency may "feel" quite different, one smooth, the other hard or sharp.

At the left of Fig. 1 is shown a simple harmonic vibration, of true elliptic form, with the displacement, velocity and acceleration graphs for the 2 mils vertical amplitude at 1800 r.p.m. The right hand side of Fig. 1 represents a vibration having a 2 mil vertical component, at 1800 r.p.m., but this motion, as exhibited by the vibration figure, is distorted by impact or other causes. The reference points on the figure represent the 4 phase points, 90 deg. apart in rotation. The velocity and especially the acceleration graph for this motion have values far greater than for the simple motion, the maximum acceleration actually corresponding to the normal maximum acceleration for a simple harmonic vibration, of over three times the amplitude, or 6 mils.

In estimating the severity of a vibration it is thus important to know its character, to make due allowance for any abnormal condition or deviation from simple harmonic motion. The tolerance for one component may not agree with that permissible for the component in another direction. For example, 2 mils of vertical amplitude may create a much greater general disturbance to the unit as a whole than double that amount in the lateral direction. In fact, such a condition is the rule rather than the exception.

Individual bearings often require separate consideration. On the larger condensing turbine-generator sets with massive and rigid supporting of the No. 2 bearing, an amplitude of say 3 mils vertical would generally represent a far more severe disturbance to the unit as a whole than an equivalent amplitude at the thrust or outboard bearing. Thus a more stringent tolerance would be in order at this location.

Outboard bearing pedestals are usually independent members and their vibration is more or less localized. It is not uncommon to find amplitudes as great as 3 or 4 mils at 1800 r.p.m. in the lateral and particularly the axial direction, with little disturbance to the main unit. Thus, a greater tolerance may often be permissible for this bearing.

Amplitude Alone Meaningless

The statement that the vibration at a bearing has a certain amplitude may be meaningless, unless the location of the vibrometer is definitely specified and comparative readings always referred to that location. Almost invariably the amplitudes observed simultaneously at the two sides of the bearing show some difference, and sometimes the amplitude at one side may be double or more the other. The amplitude at the top center of the bearing pedestal cap is generally greater than at the horizontal joint flanges, particularly in the lateral and axial direction. This condition is due to a common rotary or conical mode of vibration about a node located at one side of the base of the pedestal, as illustrated in Fig. 2. Such a mode of vibration can readily be explored by means of the small hand type vibrometers, and should always be ascertained if the vibration is appreciable. It is recommended that all bearing vibration be observed at a definite location, such as the top of the pedestal cap.

Resonance characteristics of the structure as a whole may operate to allow increased tolerances, particularly if the bodily movement of the rotating and stationary parts are in unison. It is now understood that the amplitude of vibration for a given unit of unbalance at a given speed is largely a matter of accident, as it depends on the amplification factor, which is fixed by the relation between the operating speed and the resonant speeds of the several modes of vibration.

It is not yet possible to control or predetermine these resonance characteristics with any degree of certainty. Although turbine generator units may be

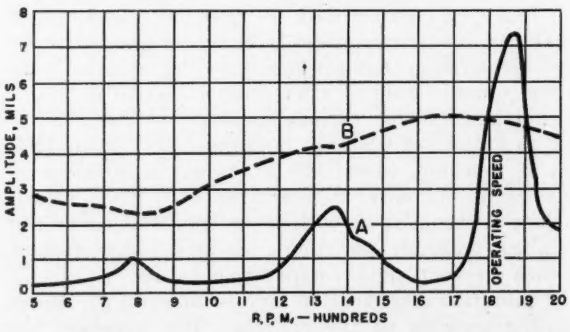

Fig. 3. Resonance curves of the vertical vibration of two turbines made from actual test data. Curves A and B are for the No. 1 bearings of two different units

identically constructed, the foundations, which play such an important role in determining the resonance characteristics, vary greatly. A pound of unbalance at the balance hole radius may cause a vibration of 10 mils on one unit, but only 2 mils on another unit at the same speed. Thus, to reduce the amplitude on the first unit, extreme refinement in balancing is necessary, due to the much greater sensitivity of response. Obviously the destructiveness cannot be in proportion, as the centrifugal forces responsible for the disturbances are roughly the same for relatively rigid rotors.

Resonance Curves

Allowance may properly be made in applying tolerances with such a situation, if a large amplification factor at the operating speed is demonstrated by actual resonance tests. Such a test merely involves the determination of amplitudes corresponding to various speeds, preferably up to 10 per cent overspeed. The plotted results are called resonance curves, and represent the inherent characteristics of the installation. Such an actual test is shown by curve A in Fig. 3. This unit had very little residual unbalance, but a relatively large resonance peak existed slightly above the operating speed. Slight changes in speed around 1800 r.p.m. or slight shifting of weight reactions due to temperature distortions in the structure resulted in large differences in vibration amplitudes, therefore the particular amplitude observed at 1800 r.p.m. has less significance. Curve B, on the other hand, although having a smaller value at 1800 r.p.m., represents a much more serious disturbance.

These facts indicate that a better criterion might be based on the amount of residual unbalance rather than on the resulting amplitude. With the more modern field balancing apparatus now available which determines the phase as well as the amplitude of vibration, the residual unbalance is readily determined by the unit vector process. When unusual sensitivity is encountered, the residual unbalance information actually should be recognized in establishing a tolerance.

Resonance, or great sensitivity for small unbalance cannot, of course, serve to condone a vibration which is palpably hazardous to the unit. Resonance of individual parts and appendages, such as the steam lines, governor dome, valve chest, etc., unless corrected by structural alterations, may require more stringent tolerances in the bearing vibration.

The general mode of vibration of the installation at the operating speed may result in a node or dead point occurring near one or more bearings. In such a case, the general disturbance of the unit as a whole may be out of all proportion to the amplitudes observed at the bearings, and individual treatment again becomes necessary. The vibration or jumping of the shaft itself, apart from the bearing vibration, may aid in estimating the condition of the unit, if the reference location on the shaft is known to be smooth and concentric with the journals. Where the general vibration is great but the bearing vibration is small, the shaft motion itself may disclose an unsatisfactory

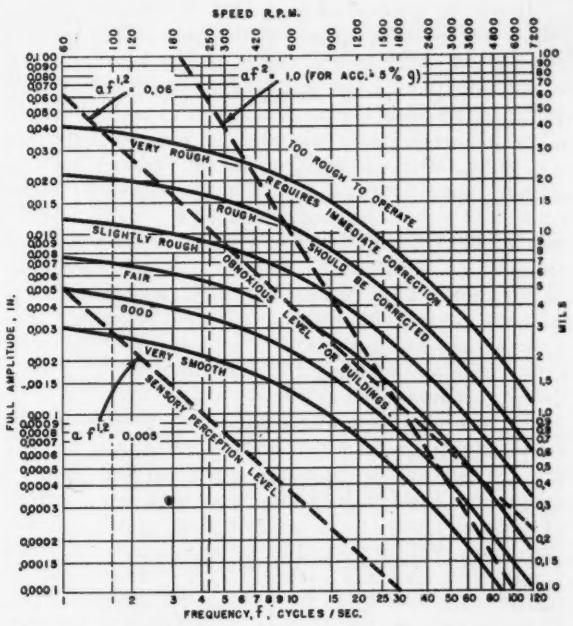

Fig. 4. Machinery vibration tolerance chart

condition, but large bearing vibration may exist with little relative motion between the bearing and shaft.

In estimating the general disturbance to the unit as a whole, the experienced observer will not be deceived by the clatter and chatter sometimes set up by loose floor plates, hand rails and the like, which may occur even with a smooth running unit. He is concerned however, with the vibration of the piping, linkages, governor and other appendages, the general vibration throughout the entire structure and surroundings, and the noises heard in the bearings and cylinder parts with the listening stick.

Danger Point

The magnitude of vibration that is almost certain to cause damage is of course problematical. One important factor is the closeness of the clearance between the stationary and rotating parts, and whether the rotor vibration is in or out of phase with the movement of the stationary parts. The possibility of great shaft deformations as a result of rubbing contact is important. The author once witnessed a vibration at the No. 1 bearing of a large 1800 r.p.m. turbine which reached a momentary value of 30 mils, with no ensuing damage. This is exceptional, as blading and packing rubs causing damage have occurred with vibration less than 8 or 10 mils, at this speed. Continued large vibration is of course, more serious than momentary peaks such as occur with sudden load changes, as fatigue of parts or bearing damage may ensue.

It is evident from what has been said, that each installation requires individual consideration, based on experienced judgment. But with the understanding that many factors prevent the assigning of hard and fast tolerances to cover all classes of apparatus, the chart Fig. 4 is offered to serve as a guide in estimating the comparative severity of the vibration of machinery.

It will be noticed at once that the graphs do not follow the inverse square of frequency law, or any other fixed index, particularly at the lower ranges. If we held to this law and extrapolated to low frequencies, we would soon reach a situation where an allowable amplitude would be great enough to disrupt the parts. For example, assuming the inverse frequency squared rule, if 2 mils can be allowed at 1800 r.p.m., then the tolerance would be 8 mils at 900, 32 mils at 450, 128 mils at 225, and 512 mils—over half an inch, on a 112 r.p.m. engine. This is obviously unthinkable. For low speed reciprocating machinery, with its unavoidable residual external reactions, it is common engineering practice to design the base with sufficient mass to limit the maximum rocking to a definite amount, such as 5 mils.

It will also be noticed that the graphs in the frequency range from 600 to 3600 r.p.m. roughly follow the slope of the proposed threshold and nuisance graphs for comfort in buildings, which were arrived at independently from physiological considerations. But below 600 r.p.m. or 10 per second frequency, the machinery tolerance graphs curve downward to smaller values, crossing the physiological graphs. This is reasonable, as the sensory perception of low frequency vibration bears no relation to the stresses set up by the movement. Experience beyond 5000 r.p.m. is somewhat meager, but the slopes extrapolated with the index $af^{1.7}$ appear to be reasonable and consistent.

Summarizing, the chart values characterizing the severity of machinery vibration represent the results of a great number of observations on many types of machines, and are based on practical rather than on theoretical data conforming to some assumed relationship. Variations of 25 per cent or more either way are to be expected in individual cases. With proper recognition of the various influencing factors described, the chart should furnish a reasonable guide for estimating the severity of vibration.

How Much Gas?

By James O. G. Gibbons

ANYBODY who may have to design, or make changes, in boiler settings, breechings, etc., will find himself in a more satisfactory position, if he has some definite idea as to the amount of gases which will have to be handled.

It is not necessary that this information should be very exact, indeed; extreme accuracy is impossible, as there are too many variables, such as maximum load, exact quality of the fuel, excess air, etc., which can only be roughly approximated. Nevertheless, we want to be in a position to make our estimates in such a way that we may have confidence in the reasonableness of the results. For this purpose, the following will be more than sufficiently accurate. The figures are based upon bituminous coal having a heat content of 14,000 B.t.u. per pound, with a combined efficiency of approximately 75 per cent, but, as will be shown later, for purposes of design, the data can be used for other grades of coal or even oil.

Air (at 70 deg. F.) required per minute, per boiler hp.
0% Excess air, per minute ..... 7.5 cu. ft.
For every 10% excess air, add ..... 0.90 cu. ft.
100% Excess air, 7.5 + 9.0 ..... 16.50 cu. ft.
Cubic feet of flue gas at 550 deg. F. per minute, per boiler hp.
0% Excess air, per minute ..... 14.5 cu. ft.
For every 10% excess air, add ..... 1.75 cu. ft.
100% Excess air, 14.5 + 17.5 ..... 32.00 cu. ft.
Weight of flue gas per minute, per boiler hp.
0% Excess air ..... 5.8 lb.
For every 10% excess air, add ..... 0.7 lb.
100% Excess air, 5.8 + 7 ..... 12.8 lb.

It is conservative to assume that there will be 20 lb. of flue gas per pound of coal, and 18 lb. per pound of oil.

Cubic feet of gas per minute, per boiler hp. at 2000 deg. F.
0% Excess air ..... 35.5 cu. ft.
For every 10% excess air, add ..... 4.5 cu. ft.
100% Excess air 35.5 + 45 ..... 80.5 cu. ft.

The air per minute per boiler horsepower will be required when estimating the capacity of air intakes, forced draft fans, etc.

The data relating to flue gases will be useful in designing breechings, estimating the capacity of induced draft fans, and stack draft losses.

The volume of gas at 2000 deg. F. will, in connection with that of the exit gases, be useful in estimating the volume of gas to be carried in the different boiler passes.

Of course, in the case of a new boiler, it may be assumed that the design is such that there will be no excessive draft losses, but very often stokers or oil burners are installed on old boilers, with the intention of increasing the rating, in which case it is well to keep in mind that this increases the amount of gas to be handled, but does not increase the area of the spaces through which it has to pass, so it is well to see that the draft will be adequate under the new conditions.

A mistake is often made in assuming that the installation of oil burners will decrease the amount of draft required, and enable the present stack to carry a much greater load. This is true, in some cases, especially when the air is taken into the furnace through a checker floor but, with register type burners, the resistence is sometimes so great that they are equipped with forced draft fans.

As the theoretical number of cubic feet of air required for any fuel is nearly one per cent of the B.t.u. value of the fuel, and the number of B.t.u. in a boiler horsepower hour (or minute) is a constant; when operating at the same efficiency and with the same per cent of excess air, the number of cubic feet of air required is the same for any class of fuel, so if the efficiency is around 75 per cent, the data given will apply to any fuel, and all we shall have to estimate is the excess air, which will probably be about as follows:

Oil burning, 20 to 25 per cent.
Stoker fired coal, 40 to 60 per cent.
Hand fired coal, 40 to 100 per cent.

If the expected efficiency is other than 75 per cent, a correction can readily be made.

The PRACTICAL ENGINEER

DEVOTED TO PLANT OPERATION and MAINTENANCE

A. W. KRAMER, EDITOR

WHAT—NO CO_2 BONUS SYSTEMS?

In the Questions and Answers section in last month's issue an engineer at New Hope, Pa., asked for information regarding CO_2 bonus systems. He has in mind putting such a system into effect but before he does so he would like to have the opinion of others who may have had experience with such bonus systems. We published the question, assuming, of course, that we would receive dozens of letters telling C. B. O. all he wishes to know about the subject. But, so far, and it is the 20th of the month as we write these lines, not a single answer to the question has been received. To say the least, this is disconcerting. How come? Isn't there anyone among all our many thousands of subscribers who can tell this poor fellow something about CO_2 bonus systems? Surely, some of you operators must have worked with or under them at one time or another. Maybe you think they are no good. Well, if that is the case why don't you write an tell C. B. O. so; he will appreciate it and if your letter is published we will pay you for it. Suppose you are not one of the "big shots" in your plant; that does not make your opinion of the subject less valuable, assuming that you have worked under such bonus systems. The opinion of a man who has worked under such a system is just as valuable as that of the chief engineer or superintendent of power who may have put such systems into effect. And if you are a "big shot", well, your opinion is of value, too. Let's hear both sides of the question.

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A Section of Power Plant Engineering

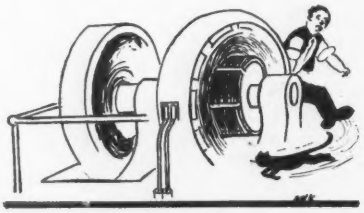
TECHNICAL PUBLISHING COMPANY
53 WEST JACKSON BLVD., CHICAGO, ILL.

A true story of a cat in a power plant leads to a more or less philosophical discussion of the underlying elements that may, or may not attract young men to the power plant field. The glazed tile turbine rooms of our central stations present only one aspect of power plant engineering. It is well to consider some of the other elements before deciding upon a career as a power plant operator.

The Nightmare of Nicodemus And Related Subjects

AT THE PLANT of the Pennsylvania Sugar Co. in Philadelphia, pussy cats in family units are domiciled in the locker room, warehouse and the machine shop under the protection of the watchmen who act as Godfathers. An official appropriation is extracted from the petty cash fund for milk and liver, alternating with salmon on Fridays. The cats are not admitted into the engine room and they usually respect the rule. The machine shop cat, however, occasionally satisfies her curiosity to stroll into the adjoining boiler house.

One night not long ago while Nick, the watch engineer, was on duty a strange four legged visitor attired entirely in black fur came into the refinery, presumably to make a call on her



She careened around the generator

friends. Not being familiar with the layout of the place, she somehow lost her way and, ignoring the prohibition against pussy cats, strayed into the engine room.

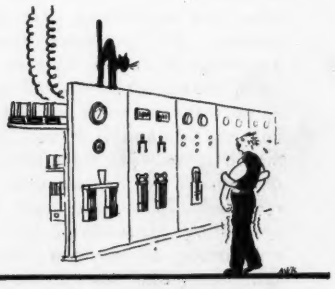
The bright lights and whirring machinery were not conducive to her gentle temperament and stampeded her into fright. After the first burst of speed she careened around generator No. 2 and nearly jumped over the flywheel pit. If she had acted on the impulse, she would have had to finish out the week inside the rim. Nick was standing close by but she dodged him and made straight for the middle of the d.c. switchboard. Nick was biting his tongue. In a jiffy she had mounted from one switch to another and reached the top of the board, which was about an inch and a half thick. Here she paused to survey the situation. It was none too good.

By this time Nick's hair was standing on end and he was debating whether to shut down the plant or let the cat do it! A couple of feet below kitty's perch were long lines of "hot" bus bars. A little feline indiscretion could put the works on the blink. Nick was beginning to sweat blood—he closed his eyes and said a few prayers while he waited through eternity for the fireworks to begin.

But nothing happened. His predicament received providential recognition when pussy suddenly disappeared over some wires above the bars and was seen no more.

When the report was noted in the log, an explanation was demanded from Nick. Didn't he know that the rules forbade "Red eye" in the engine room? Nick was exonerated, however, as pussy's "fingerprints" were plainly marked in the dust on the switch handles and on top of the board. Fortunate it was for Nick that the annual boiler house cleanup provided a coating of dust to support his report.

So much for that story—I picked it up, as you will surmise, from that great compendium of humor, philosophy and engineering information, Dan Gutleben's log, and present it here for no other reason than that it is amusing. It has no moral and it is not likely that Nick's experience will be of any help to others who might encounter a cat in the engine room. Nick was quite helpless, as anybody else would have been and anything that might have happened would have been classified as an act of God. The cat showed his good sense, a great deal more



She paused to survey the situation

than the workman who, while doing some temporary work in an engine room, looked for a safe place to put his dinner pail, and saw the bus bars which seemed to offer a convenient area of support. He acted on the impulse, which was unfortunate because the buses were hot and what happened afterwards could under no circumstances be called an act of God. Why not? Because the workman presumably was a rational being and should have been able to relate cause and effect. The cat, on the other hand, knew nothing about cause and effect but she had instinct and that instinct, in this particular case, was more effective than the workman's power of ratiocination, or lack of it.

Sometimes I feel that practical engineers are possessed of a certain kind of instinct which enables them to anticipate trouble or dangerous conditions, but perhaps that is only the net result of their long experience. Watch an experienced rigger—note the almost studied abandon with which he will throw a chain around a heavy object to be lifted and the nonchalance with which he slips the hook into place. Does he ever doubt whether it will hold,' I think not; somehow he knows that he did it exactly right. The

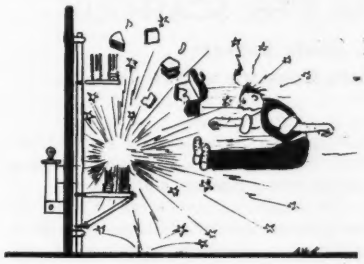
novice would have spent ten times the amount of time doing the same task and then at the instant the crane began to lift the load, his heart would practically stop lest the whole thing should come undone.

Last month in these columns we referred briefly to the old time engineers who could tell by the click of the valve gear whether or not the Corliss engine was running properly. That is a form of instinct. In the modern turbine room the same quality enables the operator to detect slight variations in hum or vibration which if unheeded would spell disaster.

These things are not things that can be taught in the same sense that the principles of combustion can be taught. As editor of a power plant publication young men have come to me for advice at various times as to how to become a power plant engineer. What should they study and how should they get started? What do they need in order to pass the license examinations?

Well, you men who are operating engineers know that the things which enable a man to pass the license examinations cannot be learned at school. There is nothing wrong with school and there are many things of value to the practical engineer that he can learn at school, but the real business of operating must be obtained in the power plant—in the atmosphere of boilers and engines, generators, pumps and condensers. Put a young man in the power plant and let him work there for a year or two and then if he has the instincts which make a man an engineer, they will show up; if not, he won't last a month.

It is no simple task for a young man to get a job in a power plant these days so that it is difficult to advise such men

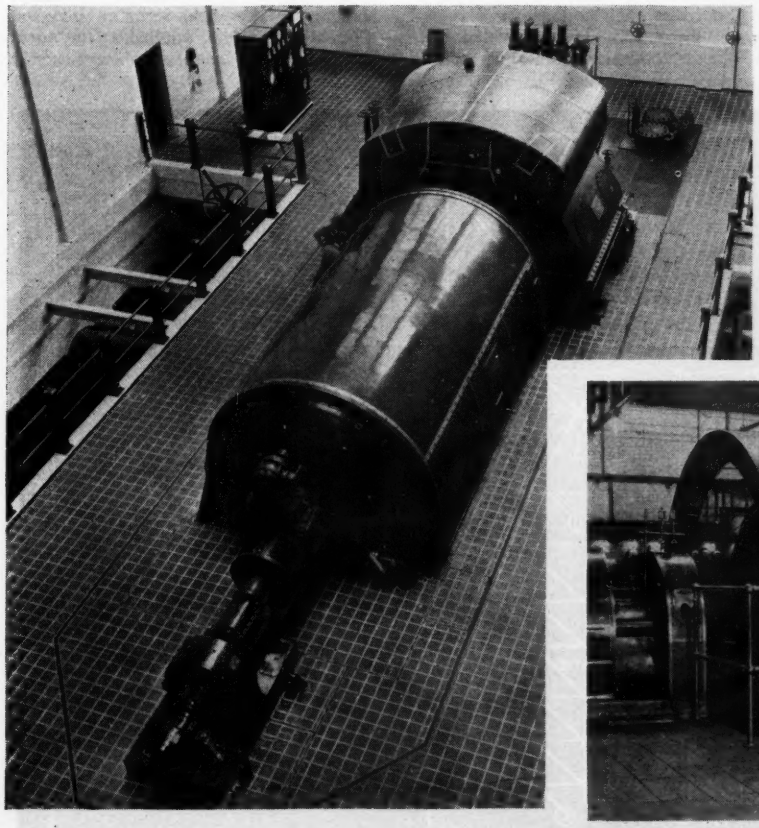


He acted on the impulse

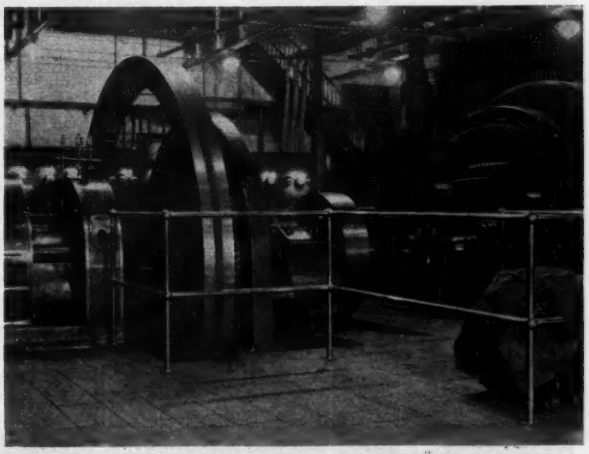
what to do. I tell them to call on engineers at their plants, not with the object of getting a job but to talk to them and to see what a power plant looks like. In this way they will at least see a variety of plants and they can then judge for themselves whether they want to become operating engineers. Many a young man who as a consequence of a chance visit to a glamorous public utility station imagines that he wants to be an engineer whereas if he really knew what many power plants look like, he would be wary of them as the cat in the first part of this article. The cat's instinct told her that the engine room was no place for her and it is quite likely that many young men would react in a similar fashion. White tiled power plants are swell to look at but the tile is largely camouflage for hiding complicated masses of pipes and wires and the power plant engineer's concern is with the pipes and wires, not with the tile. Some power plant work is extremely disagreeable and in old plants where more or less ancient equipment has to be kept in operation, there is a great deal of drudgery. Cleaning and repairing boilers, overhauling pumps and engines are dirty jobs not suited to one who likes to keep his hands clean. In times of emergency, in cases of floods and fires, the operating engineer's lot is a particularly hard and sometimes dangerous one. And while the firemen who put out the fire get their names and pictures in the paper as heroes, the operating engineer who kept the pumps going at the risk of his life, remains unsung and unnoticed. I remember one case of a fire in a big office building where the engine room tended to become flooded, the engineering force worked all night in slime, cold water and darkness, while sash weights dropping from the burning windows 16 floors above tore through the concrete sidewalks below which the pumps were located. It was no fun but the engineers stuck to their jobs—or was it their job?

Many men would not have thought a mere building important enough to risk their lives, but engineers are not constituted that way. The pipes and wire and machinery to them are the most important things in the world and they know their duty is to keep them in working order. If a young man's interests and instincts run toward pipes and wires, well and good, he will make a good engineer, but if they are in the tile, he should get a job in a bank—or become a tile setter.

A. W. KRAMER



Some power plants look like this—



But more look like this—

CONSTRUCTION AND REPAIR

THE ERECTION OF TUBULAR STEEL SCAFFOLDS

By W. Elwood Rossnagel, Safety Engineer
Insurance Department, Consolidated Edison Company of New York, Inc.

TUBULAR scaffolding has become very common in recent years, not only on large construction and alteration jobs, but on small isolated jobs as well. The larger installations are usually erected by the company furnishing the equipment, but many of the larger manufacturing plants and contractors have supplies of the tubing, clamps, etc., and erect small scaffolds for such work as painting ceilings, installing overhead piping, repairing window frames, and a hundred and one other jobs.

Usually these smaller scaffolds are erected by the men who are about to use them, being thus built by painters, pipe-fitters, carpenters, etc. None of these gangs use the scaffold frequently enough to be thoroughly familiar with all the "tricks" of the trade. It is not the intention of this article to divulge all these "tricks" of erection, but rather to call to the attention of those responsible for the erection of tubular scaffolding, and built-up wood scaffolds as well, the necessity of adequately bracing the structure against collapse.

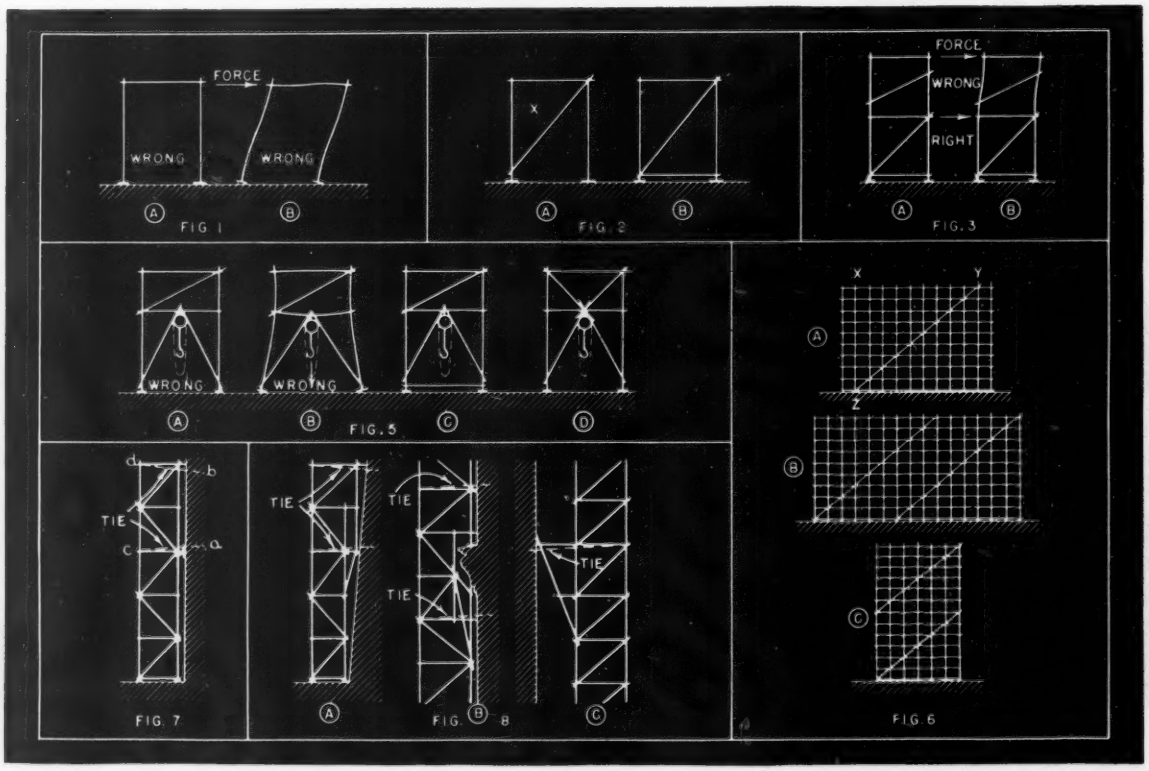
To begin, all structures in order to be assured against collapse, should be made up of triangles, or at least a sufficient number of triangles, to properly support them. It is assumed here that the rigid 90 deg. pipe clamps are used to join the vertical posts and the horizontal members, the latter being known as "ledgers" when they extent longitudinally and as "putlogs" when they run transversely. A frame, or "bent," consists of two posts and the necessary horizontal and diagonal members. If such a bent is constructed as shown in Fig. 1-A, and a horizontal thrust is applied, it will collapse as shown in Fig. 1-B, the tubing being bent out of shape while the clamps maintain approximately a 90 deg. joint.

To resist such collapse, a diagonal brace (Fig. 2-A) must be provided. This will form a triangle "X", thus making the structure self-supporting. In order to secure the other post against accidental displacement if struck by a truck or other movable object, it is desirable to install a horizontal member near the feet of the posts. (See Fig. 2-B)

In installing the diagonal braces it is important that they be clamped as close as possible to the joints of the posts and the horizontal members, as shown in the lower panel in Fig. 3-A. When constructed as shown in the upper panel true triangles are not produced, and when a horizontal force is imposed on the structure it will have a tendency to fold up as shown in Fig. 3-B, the posts being subjected to bending stress in addition to the normal compressive stress.

As the scaffold is built higher, additional panels of like triangles are created (Fig. 4-A). It makes no difference, under ordinary conditions, whether the diagonals are all parallel (Fig. 4-A) or zig-zag (Fig. 4-B). In fact, it may even be desirable to use longer diagonals (Fig. 4-C) so as to make a triangle out of two panels, but in such case the diagonal must be clamped to the intervening ledger or putlog in order to prevent possible buckling of the structure at that point.

Sometimes it is necessary to apply a concentrated load, such as chain hoist, at the middle of one of the horizontal members which has insufficient strength in bending to safely support the load. (See Fig. 5-A.) Diagonal braces are frequently added to form an inverted "V" with the load applied at the apex. If the feet of the posts are securely



anchored in place, these braces will be satisfactory. But usually the feet of scaffold structures are not secured, or if so, only by a few nails. When the load is applied, the structure will be distorted as shown in an exaggerated manner in Fig. 5-B. This condition can be avoided by using a tie member connecting the posts at the ground member so as to keep them from spreading. (Fig. 5-C.) Or, if preferred, additional diagonals may be used provided they are placed so as to prevent deflection of the horizontal member upon which the load is applied (Fig. 5-D.)

The spacing between posts, longitudinally, should not exceed six feet when used for heavy duty work such as bricklaying, etc., and not more than eight feet for such light work as painting and decorating. The transverse spacing between posts should not exceed six feet in any case. Where the eight foot spacing is used, it is sometimes necessary to reduce the span of the floor planks by placing an additional putlog midway between the posts.

On large scaffolds, several panels high and several wide, it is customary to run one long diagonal brace across the outer face of the structure rather than to use zig-zig bracing up one bay. Fig. 6-A shows the outer face of a large scaffold erected in front of a big building. This long diagonal now forms a large triangle x-y-z the height of the scaffold. Inasmuch as this diagonal is clamped to each post or putlog that it passes, the large triangle is sub-divided into a number of smaller triangles. This provides an effective bracing of the entire structure provided the bracing starts at the ground level and not one panel higher. If the scaffold is longer in relation to its height, two or more long diagonal braces may be used. (Fig. 6-B). If it is very high relative to its length, the bracing may be as shown in Fig. 6-C.

Diagonal bracing in the plane at right angle to that shown should be provided at every second pair of posts.

All scaffolds, the height of which is three or more times the least width (Fig. 7) should be secured against overturning bodily. This may be accomplished by extending the putlogs "a" and "b" so as to bear against the wall. Then ½ in. steel cables should be secured to the outer posts at points "c" and "d" and be stretched on about a 45 deg. angle (in a horizontal plane) to building columns or other firm anchorages.

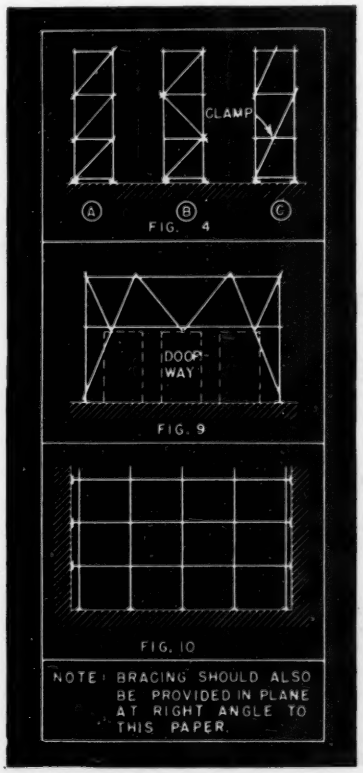
Frequently it is necessary to erect an irregular shape scaffold such as at a cornice, sloping wall or other obstruction, in which cases the posts cannot be continuous for the full height of the scaffold, but must be offset in relation to each other. See Figs. 8-A and 8-B. In each case the vertical load on the upper post must be transferred to the lower post by means of diagonal braces. Fig. 8-C shows a platform bracketed out from a tubular steel tower.

Sometimes it is desirable to erect a scaffold where the distance between posts must exceed the normal span. Fig. 9 shows such a scaffold erected inside the lobby of a public building. In this case, a truss is created by means of the diagonals which produce the required triangles. The bracing should also be extended to the feet of the posts to hold the structure rigidly.

Where scaffolds are erected inside a room and where they extend from wall to wall and bear solidly against these walls (Fig. 10), the diagonal bracing may be omitted.

There is almost no limit to the possible number of arrangements for tubular steel scaffolds, but they are all based upon the general principles mentioned at the beginning of this article, particularly the fact that the diagonal braces must be so placed as to create triangles, and that these diagonals must be clamped as close as possible to the junction of the posts and ledgers or putlogs. Of course, there are other safeguards to be considered. The scaffold planks should be high grade lumber amply strong to support the load placed upon them. They should be so placed that it will be impossible for a man to step on a long cantilevered end and cause a plank to tilt and allow him to fall; on the other hand, the plank should overlap far enough to avoid the possibility of slipping off the putlog. On the exposed sides of the scaffold decking, planks should be secured on edge to act as a toeboard to prevent objects from rolling or being kicked off the platform.

Also, pipe members should be run horizontally about 42 in. above the floor to afford the necessary handrail protection; in fact it is advisable to also provide an additional member midway between the main handrail member and the toeboard.



REFRIGERATING PRACTICE

Refrigeration Expansion Valves

By H. T. Lange*

FIVE TYPES of expansion valves are or can be employed in air conditioning namely: the hand; constant pressure; high pressure; float; low pressure; and the thermostatic expansion. Some are suitable for this work and some are not, but all are included in order to emphasize why a certain type of valve either will, or will not, work satisfactorily on air conditioning work.

Almost all plants in the air conditioning field which involve the installation of an expansion valve as an accessory employ for this purpose the thermostatic expansion valve. This type is the most complicated in construction, operation and servicing, and it constitutes about 90 per cent of the application engineer's contacts with expansion valves.

*Spoehrer-Lange Co., St. Louis, Mo. These comments on expansion valves for air conditioning were taken from material prepared for the Westinghouse Air Conditioning Application Engineering School.

For many years hand expansion valve was popular for all kinds of refrigeration. As its name implies, it consists merely of a globe or angle type valve with undersize orifice and a steeply tapered stem permitting close contact of the port area. Its advantages are: 1, simplicity of construction; 2, low cost; 3, reliability; 4, can be paralleled with other valves.

Its disadvantages are: 1, not automatic; 2, will not close during off cycle; 3, requires normal setting to compensate for any change in load and pressure drop across the valve.

In spite of these limitations some are in series, in combination with electrically operated liquid valves, on air conditioning plants but they are emphatically not recommended for this work.

CONSTANT PRESSURE VALVE

The constant pressure or so-called automatic expansion valve was the first automatic expansion device. The greatest use for this valve is in domestic refrigerators and to a smaller extent for

commercial application of constant load such as bottle coolers, ice cream cabinets and, to a small extent, meat coolers and display fixtures. I have seen this type of valve applied to air conditioning plants in an attempt to keep the suction pressure constant, but with disastrous results.

Its advantages are: 1, reliability; 2, will close during off cycle; 3, low cost; 4, will adjust itself for change in pressure drop across valve. Its disadvantages are: 1, will not parallel with other expansion valves, either the same or other types; 2, will not compensate for load change. Because of the fact that an air conditioning load is a variable one, it is not recommended.

The High Pressure Float Valve

The high pressure float, so-called because the action is obtained from the high pressure side of the system, acts as a trap very similar to a steam trap, and allows liquid to flow from the high to the low sides but prevents the passage of vapor. In other words, it provides the liquid seal, essential to the refrigeration cycle.

For small self-contained refrigerating units the high pressure float valve deserves serious consideration. It has, however, two serious disadvantages as applied to a larger plant, assembled on the job. First, the amount of refrigerant must be exactly right and the amount of refrigeration as well as the superheat depends on the quantity of liquid used. Any loss due to leaks will be quickly noticed in the results. Second, it cannot be paralleled either with another high pressure float or with any other expansion valve.

Its advantages are: 1, reliability; 2, low cost; 3, will allow suction pressure to adjust itself to changes in load; 4, will close during off cycle. Its disadvantages are: 1, cannot be paralled; 2, requires all of the liquid to be carried in the evaporator with no excess in the receiver; 3, must have surge tank at evaporator outlet; 4, provides no superheat adjustment except by varying the amount of refrigerant.

The Low Pressure Float Valve

Almost identical in appearance with the previous one, the low pressure float valve is very different in its application and effect. It must be mounted at exactly the same height as the desired level of liquid in the evaporator and it maintains this load regardless of anything except shortage of refrigerant. Contrasted to its contemporary, this valve is too expensive to apply to small units but has its chief application in the largest plants, particularly those employing cold water or brine.

The reason for this high cost is not in the valve itself, but in the fact that an expensive header coil construction and large accumulator must be used. Also, a large amount of refrigerant is generally necessary and special provisions must be made to return the oil to the crankcase. It is highly recommended for large air conditioning plants, particularly for brine and water coolers of the shell and tube type.

Its advantages are: 1, reliability; 2, will allow suction pressure to vary with load; 3, will close during off cycle; 4, can be paralleled with any or all types of expansion valves; 5, provides highest evaporator capacity per unit of surface. Its disadvantages are: 1, high cost of coil construction; 2, no superheat adjustment; 3, requires large amount of liquid; 4, space required by accumulator.

This Disconnected Valve Exploded

By W. F. Schaphorst

After many years of experience with valves this writer learned for the first time today that a valve entirely disconnected from its pipe line can "blow up" and prove fatal to anyone who may be near.

An ammonia valve had been removed from the pipe line and a blow torch was being applied to it.

The workman did not know that ammonia was trapped within the valve. The heat from the torch built up sufficient internal pressure to blow the bonnet off, the force of the disruption being sufficient to break the man's neck and cause his death.

All of which should teach all of us a lesson, namely, that before heating a valve or anything else to a high temperature, make certain that there are no trapped liquids within the object being heated. Trapped water can be just as dangerous as ammonia.

For example, when bending pipe packed full of sand, explosions have been known to occur due to wet sand. Upon heating, steam is generated, and the steam pressure becomes a source of danger.

Similarly, when babbitting bearings, make sure that the bearing is dry. Hot babbitt was once blown into one of my eyes by the steam that was generated, a mishap that made me cautious ever after.

Basement Ventilation

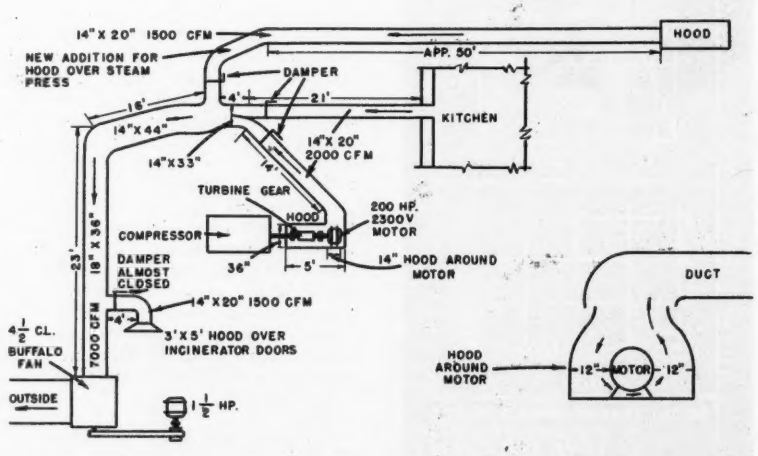
By J. H. Bieze, Manager
Scarbrough Building
Austin, Texas

Our plant room in basement was formerly very uncomfortable for employees to work in as the temperature ran about 102 deg. F. during the hot summer days with no ventilation of any kind. We have an outside stairway from the alley, one door and one window 14 ft. below the alley level.

Most of the heat in the plant room was coming from a 200 hp., 2300 v. motor driving a Carrier compressor. We installed a ventilating system with a No. 4½ CL Buffalo Limit-Load ventilating fan V-belted to a 1½ hp. 220 v. motor. The writer asked a ventilating engineer to help in laying out the duct work and size the ducts and openings. The engineer recommended: one opening over the incinerator to take 1500 c.f.m.; one to the kitchen of the basement restaurant, 1500 c.f.m.; one for grids (we have a variable speed motor for the compressor), 2000 c.f.m.; and one over the motor and Terry turbine combined, 2000 c.f.m. This gives a total of 7000 c.f.m.

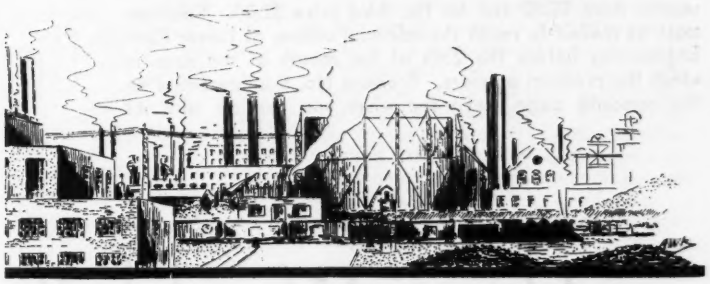
The writer asked this engineer and two others about enclosing the 200 hp. motor. The answers ran: impractical; absurd; crazy idea,. etc., etc. I ignored their advice and enclosed the motor as planned. It worked out to my entire satisfaction and the result has been better than hoped for and the motor runs cooler.

Now the temperature in our plant room is around 92 where before it was 102 deg. F. Air is better than before. We leave the door and window open and take in fresh air through these two openings.



Details of duct and hood arrangement used to improve conditions in the basement of the Scarbrough Building.

LETTERS AND COMMENTS



One Man's Reaction To License Laws

I HOPE your interesting magazine will find space to insert the following.

Power plant engineering may mean one thing to some engineers, but there is more than one way of doing it. This is one of the many ways.

Powerplants
Obliterate
When
Engineers
Revert

Prorogate
Loaf
And
Never
Try

Engineers
Never
Gain
International
Notice
Eluding
Every
Responsibility
Industries
Necessarily
Give

I feel that every person responsible for boilers, engines, or any equipment that will spell disaster if not attended to, is a potential murderer if he gets lax on his job.

Occasionally, one reads of boiler explosions causing serious personal and property damage. All this can be averted by proper license laws, and the employment of competent men.

Power plants are made to revolutionize industry, not destroy it.

It is about time all engineering organizations, power plant owners, and all those concerned get together and put a stop to this folly.

I may go a step further and say that there should be standard Federal laws governing power plants and engineers. As it is today, one can work without a license on one side of a city line, and not on the other. (Sometimes only a matter of "across the street".)

No doubt this letter will bring criticism; well, all I have to say the more the better, because every one will indicate its author is workin' on "the skin of his teeth". Indeed some readers will say "the writer is an old timer who has it all cut and try and does not worry about any stiff exams".

On the contrary, I'm only an engineer for the past four years, and would be willing to go back to the "banjo" if unable to qualify for an engineer's position.

Hoping to get readers' opinion of the above.

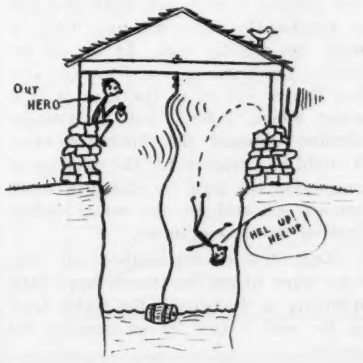
Yours truly,
MATTHEW W. PAWLOWSKI.

The Splash Method Solution of Problem 3

DEAR EDDY:

Damn your buttons!

I'm the kind of a guy that can take a drink or leave it alone; consequently, I never get drunk, and always have a good time. But I ain't that way when I see a problem. I can't let them alone, and I won't stand for any kibitzin'. I remember a problem I had in college. It was a simple thing: just had to find how high you could build a certain brick wall before it would collapse from its own weight. Well, sir, I worked that problem, and got a brick wall so high that I had to invent a stratosphere plane in order that the masons could lay the last courses. I worked on that problem, on and off, for three months—I really mean this—before I discovered that I had been using Young's Modulus for steel, instead of for brick.



What's all this lengthy preamble got to do with you? I just want to give you some background, so you will realize what your durned old "Practical Engineer" has done to me. Last issue I see two perfectly simple conversion formulæ for converting Centigrade readings to Fahrenheit:

$$C = 5/9\ (F + 40) - 40,$$
$$F = 9/5\ (C + 40) - 40.$$

Says I: That's a new one on me. I don't believe it will work.

So I tried about a dozen conversions, and by golly! she did work. So then I had to find out why. That's why I hate the sight of your old magazine; I laid awake for three whole nights thinking about the darned thing, before the very simple and obvious explanation occurred to me.

I hope you get lumps in your mashed potatoes, and that your herring smells from pork, you old such and such!

To make matters worse, I *would* have to notice that crack about a fellow who wants to measure a well. I have figured three ways* in which this might be done. Well! Well! Well! (Please note that this last remark was inserted in the hope that you are sufficiently human to grit your teeth and say: Grrrrrr.)

Let's take a look at the enclosed pictures. You will notice that they have been drawn by Michelangelo with some help from Rembrandt.

Fig. 1 works as follows:

Water level rises, raising float, A, causing rope, B, to flap in the breeze. Tuning fork, C, begins to vibrate in sympathy with rope, B, scaring unemployed piano tuner, D, and causing him to fall into well. Falling piano tuner wakes up our hero, E, who pushes stop-watch, F. When the splash reaches our hero's ears, his reflexes cause him to punch the watch again. Now, by messing around with the well-known expression

$$s = \tfrac{1}{2}\,at^2$$

and making due allowance for the time it takes the sound of the splash to reach our hero, the water level can be easily (Ha! Ha!) computed.

Cordially yours,
GEORGE P. RETTIG.

New York, N. Y.

*ED. NOTE: The other two were not worth mentioning.

In this section we provide a monthly contest in which three prizes are offered for the three best solutions to a specific problem, a new problem being presented each month. For the first prize we offer a cash award of $15.00; for the second prize $5.00 and for the third prize $2.00. Solutions must be mailed to reach the editorial offices of Power Plant Engineering before the 25th of the month of the issue in which the problem appears. Problem No. 5 is presented on the opposite page. Let's see what you can do with it?

How Would You Do It?

THE MEMBERS of our Board of Judges are in a bad way; in fact, they are almost "nuts." For over a week they have sat behind locked doors reading answers to Problem No. 3, first conscientiously, then frantically, and finally, hopelessly; none of them have slept and all are haggard and worn. At times their incoherent mumblings can be heard—some nonsense about multiplying deep well pumps by 2.308 and dividing by copper tubing but it doesn't make sense. Our staff psychiatrist does not offer much hope; Problem 3 he claims was too much for them.

Despite their sad plight, they managed to fulfill their sworn duty and just before they passed out they reached a verdict and succeeded in awarding the prizes, but they insisted, they'd be hornswoggled if they ever tackled a deep well problem again.

It seems that, except for our hero, everybody in the country knows how to measure the level of water in a well and *nearly* everybody knows how to do it by means of air pressure. Three-fourths of all the answers submitted proposed dropping a small air line into the well and then measuring the water level by means of the air pressure required to balance the static head. That was the immediate cause of the judges' confusion—every letter they read proposed the same method and for a while it appeared that they might have to give everybody first prize, including Pulverizer Pete. Finally, however, they found a letter which proposed a different idea, an electrical scheme and soon there were others, but the pneumatic method remained by far the most popular.

There is no question but that the use of the air pressure method will solve our hero's problem but is it the simplest method for his purpose? Admitting that a hundred odd feet of copper tubing costs little and that a pressure gage of some sort can be found lying around most any plant, still, the fact remains that the system involves complexities not inherent in some of the other methods suggested. The air pressure method, however, was so universally recommended that it could not be ignored in making the awards, so, in making the first-prize award the judges picked a letter which presented two schemes, first a very simple method employing nothing more complicated than a chalked gage line, and secondly, a concise explanation of the air pressure method. This letter, presented below, was submitted by Elton Sterrett of Longview, Texas.

There were other letters proposing alternative schemes but in nearly all cases the methods were more complicatd. Quite a number suggested an electrical method, using either a megger test set or a galvanometer with batteries. Among the latter was the solution by Bernard Hensgen, plant engineer of Swift and Co., National Stock Yards, Illinois, which was awarded second prize. This explanation is concise and direct and his drawing excellent.

Third prize was awarded to Mr. McKenna, chief engineer of the Union Oil Co., Seattle, Washington. This method is so simple and so effective that, unless our hero uses the chalk line suggested by Mr. Sterrett he will do well to get some of the litmus paste mentioned. Only one doubt exists in our minds regarding the effectiveness of this method in deep well work and that is whether this paste will turn white in water not slightly acid. In the oil industry, the water is nearly always acid but this is not so in the case of well water which, indeed, may be strongly alkaline. Should this limitation exist, it could be removed for the purpose of measuring the level by adding a small amount of acid to the water before making the measurement.

Regardless of the method our hero may want to use he should have little difficulty in measuring the water level in his well. Now let us consider the replies.

FIRST PRIZE AWARD

Problem III

By Elton Sterrett.

Occasional readings of water level in the deep well can most cheaply be obtained by use of a chalked gage line, suspended on a length of wire to hang at a fixed depth within the well. Water height is indicated by the line of demarcation between wet and dry tape, and can be read upon withdrawing line from well.

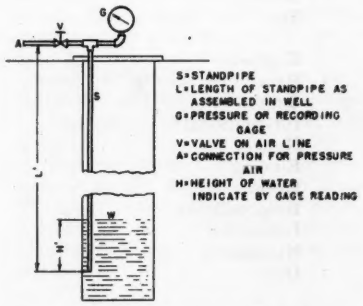


Fig. 1

With compressed air handy, an accurate check on the height of water within the well can be secured by running a pipe into the well, with its lower end projecting below lowest level of the fluctuating fluid. This pipe can be made up of half-inch or even smaller pipe, being assembled as shown in the enclosed sketch. As the pipe is assembled and lowered into the well, record is kept of the exact length of each joint, so that upon completion of the pipe run the length "L" is known.

With the line properly anchored at the top, a valve is attached to one end of the Tee capping the vertical line, and a pressure gage "G" set on the other. Air under pressure is then admitted through Valve "V" and the water which has risen within the pipe is forced out. When the water within the

pipe is all expelled, it is obvious that the pressure has reached its maximum, as any further air admitted to the pipe emerges around the free end under water and rises to the water surface as a stream of free bubbles.

With Valve "T" then closed, to cut off the flow of air through the pipe, the pressure then remaining within the system—and recorded on the gage—is that required to sustain a column of water equivalent to that extending from the bottom of the pipe to the surface of the liquid. If the gage be calibrated in feet of H_2O, the reading indicates directly the amount of head above the bottom of the pipe. If the gage be calibrated in pounds per sq. in., multiplying the gage reading by 2.308 will convert the figure to the desired feet of water.

Having once established this level or height of water as "H", this can be recorded and compared with subsequent gage indications, the pressure within the pipe varying directly as the head of water and at all times being a direct measure of the height of fluid above the end of the pipe.

Should a continuous record of well fluctuations be desired, this can be secured by attaching a recording gage in place of the ordinary dial gage shown in the sketch. Which ever method of recording pressures is followed, it will be well to admit air under pressure at intervals through the Valve "V", to compensate for any leakage of air which may occur through the fittings in the string of pipe, and also to compensate for any (although slight) absorption of air by the water at the bottom of the string of pipe.

If air under pressure be admitted gradually until the maximum required to expel water from the pipe is reached, no vibration of gage hand or indicating pen will be noted; but if the volume of air under pressure be excessive, the choke effect of the long string of pipe will result in brief periods during which too high readings will be shown. Safeguard against such pressure surges could be easily incorporated in the set-up as shown, by inserting a union between the valve and the well-head Tee. This union, of the gasket type, could be fitted with a thin orifice plate having a small hole drilled through it, so that even with the valve opened suddenly, air entering the line would be restricted to an amount which would not disturb the recording apparatus.

SECOND PRIZE AWARD
Problem III

Bernard T. Hensgen
Plant Engineer, Swift and Co.

The arrangement shown in Fig. 2 should furnish our hero with a means of obtaining water level readings as often as he would want to go over to the pump house and take them.

The necessary equipment consists of 200 ft. of copper wire, two copper weights, one 10-ft. measuring stick with a copper strip attached along one edge,

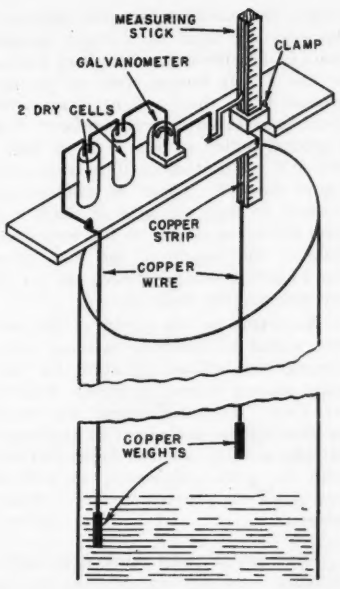


Fig. 2

two regular dry cells, one galvanometer or low range D. C. ammeter, and a 2 x 6 plank equipped with a clamping device for holding the measuring stick. Assuming that a current measuring device is already available on the plant, the out-of-pocket cost of this equipment would be negligible.

The equipment would be set up as follows: The plank would be placed across the top of the well and the battery and galvanometer fixed to the plank. A length of wire, say 105 feet, would be connected to the battery and then lowered into the water. A copper weight attached to the lower end would draw the wire taut. This wire should be long enough to assure that the copper weight would always be in the water. The remaining wire would be connected to the lower end of the copper strip on the measuring stick and allowed to hang, drawn taut by the other copper weight. Connections between battery, galvonometer, and contact with the copper strip complete the hook-up.

To determine the level of water at any time, it will be necessary to release the clamp and slowly lower the measuring stick until the copper weight attached thereto touches the water surface. The galvanometer deflection will indicate the completion of the circuit as soon as contact with the water surface has been made. The clamp is then tightened and the water level read on the measuring stick. After each reading, the stick would be raised so that the circuit would be broken. Care in lowering the measuring stick should enable one to take readings with an accuracy within 0.01 of a foot.

THIRD PRIZE AWARD
Problem III

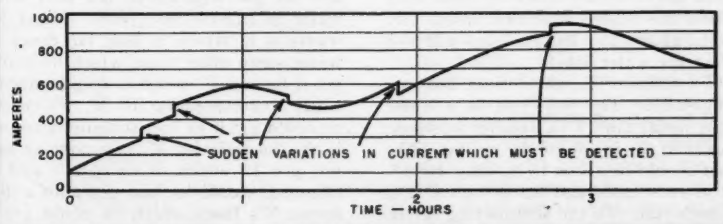
By H. McKenna,
Chief Engineer Union Oil Co.,
Seattle, Wash.

Regarding the "Water in the well" problem, as presented in Power Plant Engineering for September.

The best and most simple method for our hero to follow would be to adopt the method that is universally used

Problem No. 5

Our hero seems to have the unfortunate faculty of being unable to say no when someone asks him for help. This month again his problem has to do with a process in the factory which he has been asked to solve. ¶ For use with a new electrochemical process in which a large number of electrolytic cells are involved, a 500 volt, d.c. generator has been installed. This generator supplies current to the cells. The current changes gradually throughout the day, ranging from 100 to 800 amperes, up and down over a period of hours. Due to uncontrollable conditions in the cells, however, sudden momentary changes in current are liable to occur and these changes must be detected. ¶ The chemical process has nothing to do with the problem which resolves itself simply down to this: The gradual change of current is not of interest but the sudden slight changes must be instantly detected. What arrangement can our hero devise which will notify the operator when these sudden variations in current occur? The magnitude of the sudden variations is in the neighborhood of 50 amperes and they occur with short-circuit suddenness.



throughout the oil industry for the determination of the amount of water accumulated in the bottom of refined oil bulk tanks.

A small weight is attached to the zero end of a steel tape that is lowered into the tank. As it passes through the hands of the operator, it is lightly smeared with a film of litmus paste by the thumb. The litmus paste, pink in color, turns white on contact with water.

The lightest contact between the weight and the bottom is distinctly perceptible to the operator, whereupon the tape is wound in, and a reading taken at the point, sharply defined, where the pink and white colors join. This reading, plus the overall length of the weight, will give the depth of the water to a fraction of an inch.

In practice, the operation takes less than three minutes.

One hundred fifty foot tapes are available, but if our hero wishes to use the more common 100 foot length, he would have to suspend the tape case by a string, after the entire tape had been run out.

The litmus paste used in our plant has the trade name, Gage-O. Water Finding Paste. And is put out by the Petroleum Specialty Co., Los Angeles, Cal., at 75c a tube.

GENERAL COMMENT

The element of extreme accuracy inherent in Mr. Hensgen's method is a point that may be very important, though this aspect of the problem was not stressed in the original statement. From this standpoint a letter submitted by A. G. Solomon is of interest. He proposes the use of a simple float and weight arrangement and cautions our hero that the variation in level may be very small. Quoting from his letter:

"But I am almost positive that if there is any variation it will be so small as to be almost beyond notice. I am almost certain that there will not be a variation of more than 1 inch, more likely not even that much. I have measured several wells of different depths and in different parts of the country and I never found variations enough to even bother to measure. As the well is 100 ft. deep the water is not seepage or surface water. The water comes from a strata of sand. While the well is not being pumped there is only one way in which the water level can be changed, i. e., by withdrawing water from the same strata at a point comparatively close to the well. As all wells are encased down to the level where the water is drawn from, any strata above the 100 ft. level will not affect the water level.

To measure the water use a float arrangement. The float can be a water tight metal tank 1 in. smaller in diameter than the inside of the casing. The float should be about 18 in. long, rounded at both ends and fitted with a ring at each end. To the bottom ring fasten a 1-lb. weight—a piece of window sash weight is excellent for this purpose. Suspend the float by a light weight chain or flexible wire. The best way is to use a soft strong wire up to the ground level, then a light chain with short links to go over the pulley. Use a ground pulley at least 6 in. in diameter and locate it about 10 ft. above the top of the well. It can be mounted on a board so that the wire or chain will pass down the center of the well case. Balance the weight of the float by a flat weight midway between the top of the well and the pulley."

No report on the results of the contest would be complete without mentioning the brilliant solution by that giant among mental geniuses, Pulverizer Pete. His letter, indeed, had much to do with the sad plight of the board of judges—they couldn't figure out just who was nuts. However, we will let you judge for yourselves—here's Pete's letter:

Dear Editor: The other day when I shoulda been workin' I picks up the September PPE and starts readin' it. There's a lota big words I gotta skip but I gets along pretty good with the pitchers. So pretty soon I comes to where you tells about your pal, Hero, what has got Problem No. 3 bitin' him.

And then I gets this big idear, which is really two idears, to do you and your Hero a favor. First, I tells this Hero guy how to find out how deep is the water in his deep well today, tomorrow, etc., and second, I makes my answer so good you don't have to worry about who gets first prize but you younanimusly gives it to me with a clear conshence.

Now, sometime long ago I picks up a book called Psychics or something that has in it

$$PV = P'V'$$

which we both know is Greek and I wonders why. But today I realize it is a formula for to find out how deep is a deep well. So what has your Hero got? (Rhetorical, I answers it myself.) He has got or can get

P—which is atmospheric pressure in well one day.

h—with a fish line and hunk a wood for a float he measures how far down is water in well same day.

d—is diameter of well.

$$V = \frac{\pi d^2 h}{4}$$

He has now got V, too, which is volume of the well above the part with water in it, still same day. What he wants is h′ which is how far down is water some other time, which he could get if he had V′ which is volume above water corresponding to h′, which V′ he could get if he had something to put in the formula for P′. So now he has not got P′ which, if he had it and it changed, would let him get a lot a different V's from which he could get a bunch of h's which he wants.

Now here is how to get P′ and make it change around. If the water level goes up or down air comes out or into the well unless it is plugged up (Capped, not filled solid.) If it is plugged up, when the water drops the well gets full of a vacuum and when the water rises the well gets full of a pressure and P′, which is the pressure in the well, changes. Consequently your hero has got to plug up (cap) his well, almost. (See Fig. 3.) The almost is for to attach a pressure-vacuum gage or U-tube or something what tells how P′ changes. See picture. If your hero

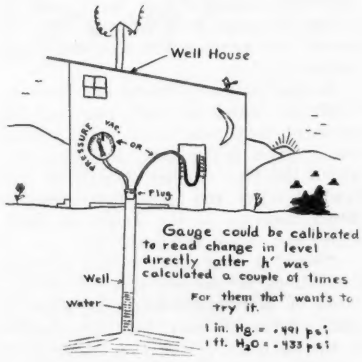

Well House
Plug
Gauge could be calibrated to read change in level directly after h′ was calculated a couple of times
For them that wants to try it.
Well
Water

Fig. 3

had a recording barometer with a pointer what didn't go off the scale with changes in P′ it would be the nuts for he could figure h′ anytime he wanted it. Otherwise he figures it only where he reads P′. If he uses a U-tube he should start with kerosene in it, if the kerosene comes out, he tries water, if the water comes out he switches to mercury; if the mercury comes out he goes to gages and if they blow up he's got a geyser not a well.

So now having gotten P's galore your Hero is all set.

$$V' = \frac{h'\pi d^2}{4}$$ and from what has went before

$$\frac{Ph\pi d^2}{4} = \frac{P'h'\pi d^2}{4}$$

$$Ph = P'h'$$ which is Latin as we both knows

and by this time it probably dawns on everybody that d ain't needed which is why I didn't tell Hero to measure it.

In case anybody wants to get real fancy; you gotta divide Ph by by the Absolute temperature, T, in the well the day you measured P and keep a thermometer in the hole to get a reading T′ for every value of P′ and divide it into P′h′. What I mean is

$$\frac{Ph}{T} = \frac{P'h'}{T'}$$

(T.abs = T Fahr. + 460)

$$h' = \frac{PhT'}{P'T}$$

h′ — h = actual change in water level. but I wouldn't bother unless you runs your tests from summer to winter.

Very truly yours,

PULVERIZER PETE

X—his mark

P. S.: Maybe this won't work.

PP

Maybe some of you think Pete's cockeyed. Well it is not our purpose to argue the point, but before you pass judgment read the letter by another brilliant genius—a fellow by the name of Rettig—which we present on another page of this issue.[1] The reason we do not present the letter here is because it reached us long after the closing date of the contest had passed and therefore was ineligible—a circumstance which we admit relieved us a lot.

Several others beside Pulverizer Pete proposed a pneumatic arrangement without using external air pressure. The arrangement by Delphin J. Palmer, for example, is similar to Pete's except he uses the homemade manometer type of gage shown in Fig. 4. This scheme would probably work except that it might be affected by the air content of the water and though it might be accurate enough for all

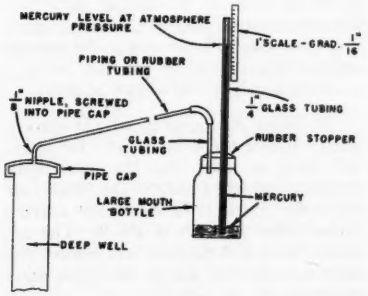


Fig. 4

practical purposes, its accuracy would not be assured.

Measuring Pressure Electrically

Among the novel methods suggested, an electrical scheme submitted by Richard Preston of Evanston, Ill., is worthy of notice. Mr. Preston also presented the pneumatic scheme but since that has already been described we will discuss only the electrical method. This is shown in Fig. 5. Quoting from his letter:

"The electrical method is more complicated (than the pneumatic arrangement) and involves a good deal more apparatus, but I think this method would give more accurate results.

"As the diagram shows (Fig. 5) I have taken a piece of bellows metal and by means of a motion amplifier have connected it to a variable resistance—similar to an arrangement for an automatic voltage regulator. One can see that as the pressure on the bellows metal increases or decreases, the metal will expand and contract, inserting or

[1]See page 731.

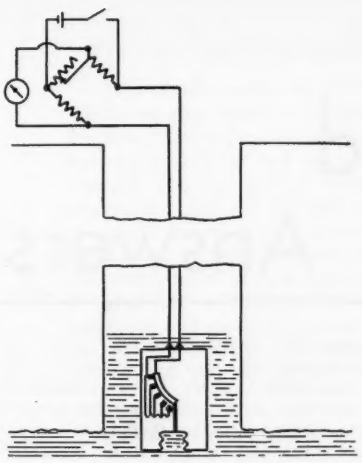


Fig. 5

cutting out resistance in an electrical circuit. This circuit may consist either of a Wheatstone bridge with a galvanometer or a battery and voltmeter and ammeter. It would be simple for our hero to calibrate the Wheatstone bridge before the mechanism was placed in the well so that so many ohms of resistance equals a pressure on the bellows of so many feet of water. Then, when the container is sealed, and using a strong wire is placed in the water, our hero will be able to read the head of water above the container directly. Naturally, the container must have one fixed level in the water and must be heavy enough not to float. In calibrating the apparatus the one hundred feet or so of wire must be accounted for. A type of metal bellows must be used which will not corrode."

Mr. Preston's scheme is novel since it measures the pressure due to the static head, electrically, and in that principle differs from all the other electrical solutions submitted, but the construction of the bellows operated controller would be a rather ambitious undertaking. The calibration also would involve time and effort and we doubt very much whether our hero would consider this method, even though, from a scientific standpoint it is perfectly feasible.

Mechanical methods are quite obvious but the actual arrangement proposed by Horace P. Storer of Pawtucket, R. I., is interesting. This is shown in Fig. 6. It consists of a rear bicycle wheel mounted on a trunion with the wheel rim over the center of the well. A fine piano wire passing over the rim reaches to a water column float at the bottom of the well. The sprocket of the wheel is connected to a driven sprocket by means of a bicycle chain, the driven sprocket having about seven times the number of teeth as the wheel sprocket. A pointer and counterweight are connected to the driven sprocket. Quoting from Mr. Storer's letter he gives instructions as follows:

"Weight the end of the wire and drop to the bottom of the well. Mark as zero the point indicated by the driven sprocket pointer. Move the bi-

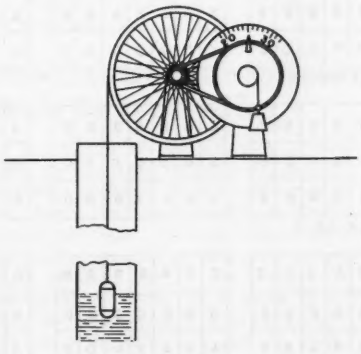


Fig. 6

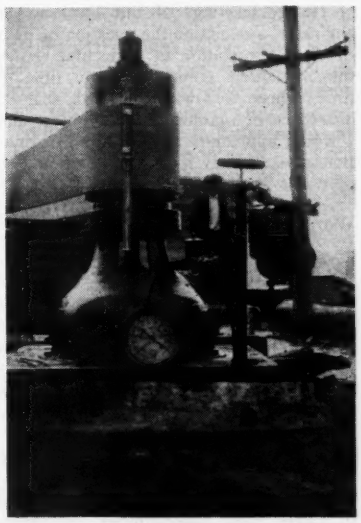


Fig. 7

cycle wheel so that one foot of wire has been withdrawn from the well and mark that point. From these points lay out graduations of a circle and number as feet. . . . If a bicycle wheel 25 in. in diameter is used and the sprockets have a 7 to 1 ratio, the wheel circumference being 7.954 ft., the driven sprocket will indicate changes of water level of over 55 ft. in one pointer revolution."

It is not often that the solution to one of these problems is so fully worked out that the contestant can submit a photograph but this was actually the case with the solution of George C. Avant of Wilmington, N. C. He proposed the pneumatic arrangement and sent in the photograph shown in Fig. —, which shows an installation which he actually worked out. This is ample evidence of the success of the pneumatic method. (Fig. 7)

Among the many fine letters proposing the pneumatic method must be mentioned that of Ray C. Barnhart of Livermore, Cal. His trouble in using the method was with corrosion of the pipe. First an iron pipe was used, later a copper tube but in each case after a number of years use failure resulted.

Questions And Answers

Wanted, Information on Circulation in H. R. T. Boilers

In the meetings of our local power engineers' association the question of path of water circulation in horizontal return tubular boilers comes up from time to time. There is always a great deal of difference of opinion on this subject and I would appreciate any definite information anybody may have on the circulation of water in such boilers.

Farrand H. Van Dyck.
Worcester, Mass.

Work Schedules—And Still They Come

The following suggestions are submitted in response to J. M.'s request for a working schedule for engineers working 40 hr. per week on a five day basis. The schedules are shown below.

It will be seen that no one schedule will comply with all the desirable features that might be asked for—rotation of shifts, equal opportunities for Saturdays and Sundays off, regular starting time for all engineers, etc. Thus for Schedule 1, the men work the same shifts each week, so there can be no danger of confusion on the point of going to work on varying dates, but there is no rotation of shifts, and "A" gets all the week-ends off while working always the midnight to morning shift. The fifth engineer always works on the day shift.

Schedule 1A shows the same arrangement except that the week ends Saturday midnight instead of Sunday midnight as for Schedule 1.

Schedule 2 provides for rotation of shifts so that each engineer works each shift every 3 weeks, and always goes to work on the same days of the week though at different hours. However, "A" gets all the week ends off while the others get their time on week days. The fifth engineer also must work each shift once in the three weeks' cycle.

Similarly Schedule 3 provides for rotation of shifts but the men do not work on the same days, and the fifth engineer rotates shifts with the others. This schedule has the advantage that no one has a monopoly on the week ends, though the periods off may be 24 hr., 48 hr., or 72 hr., once for each man in the 3 weeks' cycle, with the added irregularity that in each 3 weeks' cycle, each man works one four day week, one five day week, and one six day week.

It will be noted further that in each case, except No. 1, Saturday midnight is considered the end of the week. A number of different schedules may be made from each one shown by changing the day or the hour dividing successive week ends. However, the net result will be that some other engineer will be favored in getting the week ends off.

Pottstown, Pa. T. Holtz

	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
12 – 8	D	A	A	A	A	A	D	D	A	A	A	A	A	D	D	A	A	A	A	A	D	D
8 – 4	B	B	D	E	B	B	B	B	B	D	E	B	B	B	B	B	D	E	B	B	B	B
4 – 12	C	C	C	D	D	C	C	C	C	C	D	D	C	C	C	C	C	D	D	C	C	C

SCHEDULE NO. 1

	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S
12 – 8	A	A	A	A	A	D	D	A	A	A	A	A	D	D	A	A	A	A	A	D	D	A
8 – 4	B	D	E	B	B	B	B	B	D	E	B	B	B	B	B	D	E	B	B	B	B	B
4 – 12	C	C	D	D	C	C	C	C	C	D	D	C	C	C	C	C	D	D	C	C	C	C

SCHEDULE NO. 1A

	A	A	A	A	A	D	D	D	D	D	C	C	C	C	C	B	B	B	B	B	E	A
12 – 8	C	B	B	B	B	B	E	A	A	A	A	A	D	D	D	D	D	C	C	C	C	C
8 – 4	D	D	C	C	C	C	C	B	B	B	B	B	E	A	A	A	A	D	D	D	D	D
4 – 12																						

SCHEDULE NO. 2

	A	A	A	A	A	D	D	D	D	D	E	C	C	C	C	B	B	B	B	B	B	A
12 – 8	C	C	B	B	B	B	B	A	A	A	A	A	D	D	D	D	D	C	C	C	C	C
8 – 4	D	D	D	E	C	C	C	C	C	B	B	B	B	B	A	A	A	A	A	D	D	D
4 – 12																						

SCHEDULE NO. 3

Should Exhaust Be Run Into Stack

In the September issue of the Practical Engineer, Mr. Liccardi's problem is interesting. I would be against his solution on the following grounds:

1—Condensed steam would of course form an acid, destructive to the stack.

2—There is no mention of the volume or temperature of the gas and steam to be handled. It is possible that the temperature and volume would cool off the flue gas enough to seriously impair the draft.

Why not use this steam, condensed, as boiler feed, or as cooling water for the compressors? Or, Mr. Liccardi could install a steam exhaust pipe in the present stack. This should be bricked in.

Wingdale, N. Y. William Sheffer

If James A. Liccardi, who is considering running the exhaust into the stack, will have in mind that the stack temperature, which produce the draft for his boiler furnace, is about 300 degrees if the boiler pressure is 100 lb. The exhaust being 212 degrees will reduce the draft considerably due to the lower temperature.

We should also think of that the stack most likely is designed to lift the gasses from the boiler, and adding the exhaust will reduce the draft due to inadequate capacity.

If the stack had been short and the exhaust nozzle arranged like on a locomotive an induced draft might be the result; but the damage, in any case, that will be done to the brickwork make the idea inadvisable.

Phi' !phia, Pa. B. Hjorth

Shrinking with Dry Ice

Q. On page 665 of the October issue of Power Plant Engineering there was presented a description of a method using alcohol cooled with dry ice to remove coupling bolts from a large coupling at the Allis-Chalmers shops. I would like to know if you can give me more detailed information as to the use of dry ice in cooling metals to make tight fits in holes. In particular, I would like to know the amount of shrinkage per degree of coldness from room temperature to the temperature of the cold metal and if the diameter was much affected by this shrinkage. If possible I would like

to know the size of the bolts, length and how much larger the bolts were at shop temperature than the holes. This information is requested so that I may have it available in case I want to use dry ice in this manner when installing crank pins in reciprocating engines and similar applications.

Albert, West Va. FRED HARTMAN

A. INSOFAR as the particular case described in the October issue is concerned we can give you no further information, since the data published was all that we received regarding the process from the Allis-Chalmers Co. The question of shrinking by cooling, however, can be answered generally, however, by referring you to the tables of the expansion coefficients of metals listed in various handbooks. Within reasonable limits of temperature the principle involved in shrinking by cooling is no different than that used for many years in shrinking wheels and pulleys on shafts by first heating the parts involved. In that process, the parts are first heated by placing them in a furnace or by building a furnace around them, causing the metal to expand so that they fit easily. Then, when the metal cools to normal room temperatures, shrinkage takes place, and the parts are brought into intimate contact. In this case the hole is made larger by heating.

In the case of cooling, instead of making the hole larger by heating, the part that fits into the hole is made smaller by cooling. Then as the temperature rises to normal, expansion takes place and the parts are brought into intimate contact.

The same values for the coefficient of expansion (or contraction when the process is negative) that are used in calculating the size of the parts in the heating process are used also in the cooling method. The coefficient of expansion is the unit change in length of a body per unit change in temperature. If the length of a solid bar is 1 cm. at 0 deg. C. and we warm it up to a temperature 1 deg. C. the increase in length is called its coefficient of linear expansion and this is usually designated by the symbol a. If we take a solid bar 100 cm. long at 0 deg. C. and warm it up to 1 deg. C. it will increase its length 100 times as much as would a bar 1 cm. long. Also, if we warm the solid bar, which has a length of 100 cm. at 0 deg. to 10 deg. the expansion of this bar would be 1000 times that of a bar 1 cm. long, warmed from 0 deg. to 1 deg.

If a is the coefficient of linear expansion of a bar, than a bar l_0 cm. long at 0° C. would increase its length by l_0at when heated to t deg. C. Thus if l_t is the length of the bar at t deg. C., its increase in length is $l_t - l_0$, so that $l_t - l_0 = l_0at$.

Now suppose we consider a bolt 5 cm. in diameter at 20 deg C (68 deg F), and by means of dry ice cool it to —40 deg. C (—40 F). The coefficient of linear expansion of steel, a is 0.000012. Since the difference in temperature between 20 deg. C and —40 deg. C. is 60 deg. C we can calculate the reduction size of the bolt at —40 deg. C with reasonable accuracy as follows:

$60 \times 5 \times 0.000012 = 0.0036$ cm. subtracting

$5.0000 - 0.0036 = 4.9964$ cm. gives us the diameter of the bolt at —40 deg C.

Naturally, in this method of shrinking bolts, both the diameter and the length are affected in the same proportionate degree. The length would undergo a greater variation due to the temperature change but only in degree, not in proportion.

WE PAY YOU FOR ANSWERING THESE QUESTIONS

One of the readers of this section who answered a question which he saw there expresses his surprise and appreciation because of the check which we sent him. It was a small check but, apparently, he had not expected it. We thought we would mention this fact here in case there are others who may not understand that all answers to questions which are published are paid for at regular space rates. In announcing this here we are not doing it because we hope to stimulate interest in this department through mercenary appeal, but we realize that it takes time and effort for you to sit down and answer these questions and we want you to know that if you do, your efforts will not go entirely unrewarded. You won't get rich doing it but at least you will not be wasting your time.

How Can Cylinder Oils Be Tested?

CAN you give me a simple and practical method of determining the quality of oils? A method that any ordinary operating engineer can use so he can tell whether the oils that he is using are good, bad, or indifferent.

Lately there has been much discussion in our plant on the suitability of some of the cylinder oils. No one seems to know much about the subject, so I thought you may be able to give us some manner by which we can do the analysing ourselves, easily and practically.

Now don't advise us to have the oil analysed by some reputable chemist for we don't want that. All we want is a *simple and practical way for the ordinary engineer.*

RICHARD E. MURPHY

Mansfield, Ohio.

How Can Cracks in Furnace Walls Be Repaired?

BECAUSE of an inexperienced fireman who has now been replaced we suffered a number of severe furnace explosions in our plant. The boiler is a 300 hp. Keeler water tube unit. Although there were six explosions, the most severe caused flame to blaze out of the chimney 75 feet above the roof. It is about 25 ft. from the boiler room floor to the breeching where the boiler ties into the stack. These explosions, of course, cracked several important places in the boiler walls and one blew the top off which required several days shutdown since it is a new plant and we have only one boiler.

What I would like to know is how to repair these cracks, externally. I have tried caulking and the use of various kinds and makes of cements but it all comes out after it is dry. As it is, when the tubes are blown soot is blown over all our clean pipes. The boiler is oil fired and the former fireman was a young fellow who had never fired before and received his job through the contractor.

I will appreciate any advice or help that anybody can give in repairing these cracks.

Fairview, N. J. M. N. G.

Can Anybody Solve This Problem?

Q. I HAVE been taking "Practical Engineer" and "Power Plant Engineering" ever since 1909 and it seems to me that your new departure is the first time the little fellow has definitely been taken into consideration by any publication published exclusively for engineers. In reply to my frequent laments, the alibi has always been—"Oh well, the principles are the same." As one of your elder subscribers and occasional contributors I thank you.

So much for gratitude. Now I am coming to the Practical Engineer for some help which I stand badly in need of.

I have been having a bad time with magnetic brake motors. I can't get any help from layman or expert. The concensus of opinion is that it is a fault inherent in the type of motor and experts, knowing from experience the hopelessness of the task, simply pass the buck to the company.

On an extension of the motor shaft, friction plates are mounted. These rotate between stationary discs provided with the necessary clearance by the action of magnets in the brake head. These magnets are actuated by the 220 v. a. c. 60 cycle motor current. The brake is held open or inoperative, electrically,

against a set of recessed coil springs. When current is shut off from the motor, the springs put the brake on mechanically.

Two years ago I put in service a washing machine equipped with one of these motors. It functioned in a satisfactory manner a little over a year. Then it began to have an annoying hum which later became a clatter, and eventually, a racket intolerable in a hospital. A small boy, a stick and a picket fence could have made no more disturbance. It is of course evident that the trouble was due to the armature and the faces of the pole pieces failing to meet in the same plane and the sixty time per sec. magnetization and demagnetization.

We immediately got in touch with the nearest company representative. What we did to that motor was interesting and certainly instructive but we only made it worse. The motor company sent us a new brake head and plate and when we put it on, there was more trouble and plenty of it. Again we filed, sanded, assembled and disassembled, this time with a *new* trouble to overcome. The plate stuck to the polepieces when current was off! Eventually I overcame this sticking by blocking out the springs. The noise, however, was as bad as heretofore and the experts went home in disgust. After a time the company sent us a new motor and our troubles were over, presumably for good.

Last week, with no warning or preliminary period of disturbance, the same terrific racket broke out. Again we contacted experts. They consented, after much urging, to give the motor a dirty look, and agree unanimously, that it was a headache for the motor company.

That sort of left it up to the Engineer to look out for his *own* headache. This I have done by disconnecting the lead to the brake. There is, of course, some inconvenience, but I can invent a brake of sorts to work on the rim of the barrel drive wheel if it seems to be necessary. I tried the experiment of cutting in resistance in the brake circuit—two one hundred watt lamps in series. This demonstrated the feasibility of the idea, but proved the subdued clatter to be too loud for a hospital.

Has anyone had trouble like this and, if so, what did he do about it?

Peterboro, N. H. A. H. PARKER

Where Should the Idler Pulley Be Located?

REPLYING to the question on page 676 by C. W. L. in the October issue of POWER PLANT ENGINEERING, although the diameter of the pulleys is not given, I assume that they are comparatively large in view of the 20-foot distance between shaft centers.

If they are large—3 to 4 ft. in diameter or more—my suggestion would be to place the wrapper pulley midway between the driver and driven pulleys. In that way the increased arc of contact will be the same on both the driver and driven and the possibility of slip will be reduced to the minimum.

On the other hand if the pulleys are small in diameter—3 ft. or less—and if a single wrapper pulley will not eliminate the slip, I would place a wrapper pulley at each end of the drive, close to the driver and driven pulleys, thereby increasing the arc of contact to the maximum at each end. In that way slip should positively be eliminated.

Nothing is said about the belt being used. Sometimes a higher quality belt will take care of problems of this kind without the need of any wrapper pulleys whatever.

Newark, N. J. W. F. SCHAPHORST

Wanted. A Formula For Heat Value of Coal

COULD somebody furnish a formula suitable for determining the heat value in B.t.u. per pound of coal after an approximate analysis has been taken. We now use three different ones in computing the heat from the volatile matter. 23,600 × the percentage of volatile matter. These figures are from Marsh gas or Methane.

Then we use Kerosene rating at 20,000 B.t.u. × the percentage of volatile matter, and the last one we use is 14,600 × the total combustible percentage.

We find 23,600 and 20,000 give us a relatively high heat content, while 14,600 as used for pure carbon is much too low. Do any readers know of, or use one other than these that they have found satisfactory? We would appreciate any information along this line that you may give us.

RICHARD E. MURPHY

Mansfield, Ohio.

Determining Transformer Capacity

Q. IN A CASE where 50 electric welders are in service, it is desired to install a transformer. Each welder motor is rated at 25 hp., 440 v., a.c. The line from which current will be taken operates at 2200 v. This is to be stepped down to 440 v. for use on the welder motors. The system is 3 phase.

What capacity should the transformer have in order to carry this load? The power factor is 60 per cent.

What causes a 40 per cent drop in voltage at the end of a circuit now supplying these welders and what can be done to provide the same voltage at the end of the line as is being obtained closer to the supply end?

GEORGE BERNOVER.

Mt. Vernon, Ill.

A. It is impossible to answer the first question without more data regarding the load factor of the system. If all the welders are in operation continuously, the solution is quite simple but undoubtedly a number of the welders will not be operating at a given time and so the transformer can be of smaller capacity than would be necessary if they all operated continuously.

Assuming, however, that they all operate continuously, the total kilowatt load is obtained by multiplying the number of motors by the horsepower of each motor by the number of watts in a horsepower, i. e., 746, and dividing by 1000.

$$\frac{50 \times 25 \times 746}{1000} = \frac{932{,}500}{1000} \text{ watts or } 932.5 \text{ kw.}$$

The kv-a. capacity of the transformer can now be calculated by means of the following formula:

Kv-a. = kw. ÷ power factor

Since the power factor in this case is 0.6, the total kv-a. will be:

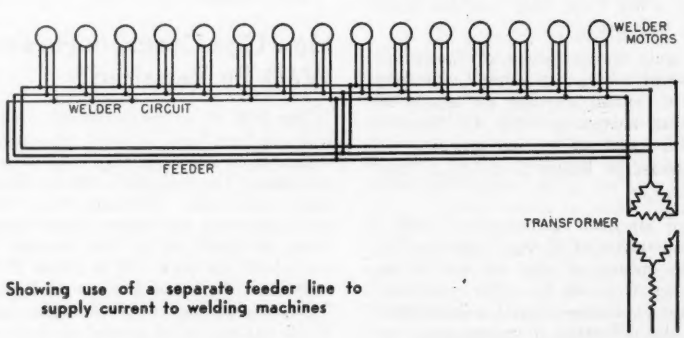
$$932.5 \div 0.6 = 1554$$

This is the transformer capacity required if all the welders operate continuously. Assuming, however, that at any one time only 40 welders are connected, the total maximum load on the transformer will be only 80 per cent of the above value, i.e.

$$1554 \times 0.8 = 1243.2 \text{ kv-a.}$$

In any event, by making studies of the load factor by means of this method you can calculate the proper transformer capacity necessary.

The 40 per cent drop in voltage which you find at the end of the line is the impedence drop of the line. The reasons for such a high drop are several. First the line conductors may be too small to carry the current. Secondly, the spacing of the conductors may be such as to cause high impedance. In the case of a relatively short line, the chances are that the drop is due primarily to the ohmic resistance of the conductors, that is, they are too small to carry the current.



Showing use of a separate feeder line to supply current to welding machines

This can be corrected in two ways, first by installing larger conductors, which may involve considerable expense, and secondly by installing a separate feeder line from which the welder circuit is fed at a number of different points. This method is shown in the accompanying diagram and is the preferable method.

Atmospheric Condenser

Q. UNDER what weather conditions will an atmospheric condenser be most effective?

Detroit, Mich. L. W. H.

A. INASMUCH as an atmospheric condenser depends on the evaporation of water from the outside surface for cooling, its action will be most effective during dry weather. When the humidity is low the rate of evaporation from the wet surface to the air is greater. The capacity is also greater during windy weather, for the wind quickly carries away the saturated air from the immediate surface of the coils and replaces it with dryer air.

Boiler Feedwater Practice

Q. WHAT is the present day practice in well regulated power plants in America with regard to the maximum limits of concentration of dissolved and suspended solid matters to be maintained in boiler water with a view to preventing foaming?

In what manner is boiler blowdown controlled as far as concentration of solid matter in boiler water is concerned?

Amagasaki, Japan. K. KIMURA

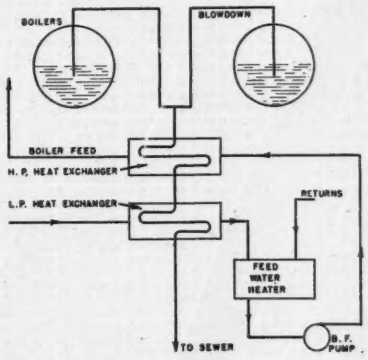
A. IT is difficult, if not impossible, to answer your first question. Published reports of boiler operating practice in large plants show wide variations in the maximum permissible concentration of boiler water, in fact they vary from a few hundred parts per million to several thousand. The size and design of boilers, the pressures and temperatures and the per cent rating at which the boilers are operated are all factors which influence the maximum permissible concentration.

In a paper presented before a joint meeting of the Engineers Society of Western Pennsylvania and the Pittsburgh Section of the A. S. M. E. several years ago, the following boiler water specifications were given as complying with what is practicable with present feedwater treatment methods and equipment.

Sodium Phosphate. With a residual hardness in the make up, 50 to 100 parts per million expressed as disodium phosphate. *Alkalinity.* Between 100 to 250 parts per million depending upon silicates which also are present. The higher alkalinity is preferred when silicate concentration is 100 to 200 parts per million. *Chlorides.* Not over 500 parts per million expressed as chlorine. Preferably as low as possible pH value. Not less than 10.5, preferably 11.0. *Sulphate-Carbonate ratio.* From 1 to 1, to 3 to 1, depending upon the steam pressure. For pressures from 0 to 150 lb. per sq. in. a 1 to 1 ratio is recommended. For pressures from 150 to 250 lb. per sq. in. a 2 to 1 ratio and for pressures over 250 lb. per sq. in. a ratio of 3 to 1 is recommended. *Oil.* None. *Total solids.* Not over 1700 parts per million.

These specifications cover the water in the boiler, not the raw feedwater.

With reference to the method of controlling the concentration, in large plants and also in many smaller plants the continuous blowdown system is in general use. Where it is not used and where intermittent blowdown is necessary the frequency of blowdown varies widely, indeed it covers a range extending from several times per day to once in 90 days or more. So many variables enter into the problem in any particular plant that the frequency of blowdown cannot be related directly to the allowable concentration, the amount of makeup or the method of treatment employed; however, there exists for each plant a blowdown cycle which will provide the most favorable combination of factors from an economic standpoint.



The continuous blowdown system mentioned above has been given considerable attention in this country. It may be used either in connection with a hot process chemical softener, or with heat exchangers designed to transfer heat to the feedwater, or with both. In the former case the water discharged from the boiler is conducted to the softener where it gives up its heat for the process, and where, at the same time, it is clarified by the removal of its suspended solids. In these installations the clarified feed water forms part of the makeup and is returned to the boiler, the only disadvantage being that in some cases the water still contains its soluble salts. In many instances the most favorable arrangement consists in conducting the blowdown water through suitable heat exchangers where it gives up its heat to the makeup or the feedwater, or both, and from which it can be discharged to the sewer. An installation of this type is depicted in the accompanying diagram. It should be noted that the blowdown connections in the boiler drum extend to a point just below the minimum permissible water level, this arrangement being provided in order that the boiler will not be completely drained in the event of an accident to the blowdown system.

What was said above regarding the control of concentration by means of an intermittent system applies with equal force to the continuous system. From an operating standpoint, the chief difference between the two systems lies in the fact that with the former the concentration may vary over a wider range than it normally does with the latter.

Since the blowdown system is such an important part of the steam generating plant it should be so integrated into the design that the desired economy of operation results from the entire combination of apparatus. In general, continuous blowdown systems for use with heat exchangers are most valuable in cases where there is a scarcity of exhaust steam for heating the feedwater, although such a system may be dictated for chemical reasons alone. In certain cases where extraction heaters are used the continuous system may not show up to good advantage from a thermal standpoint.

How to Make Dry Ice

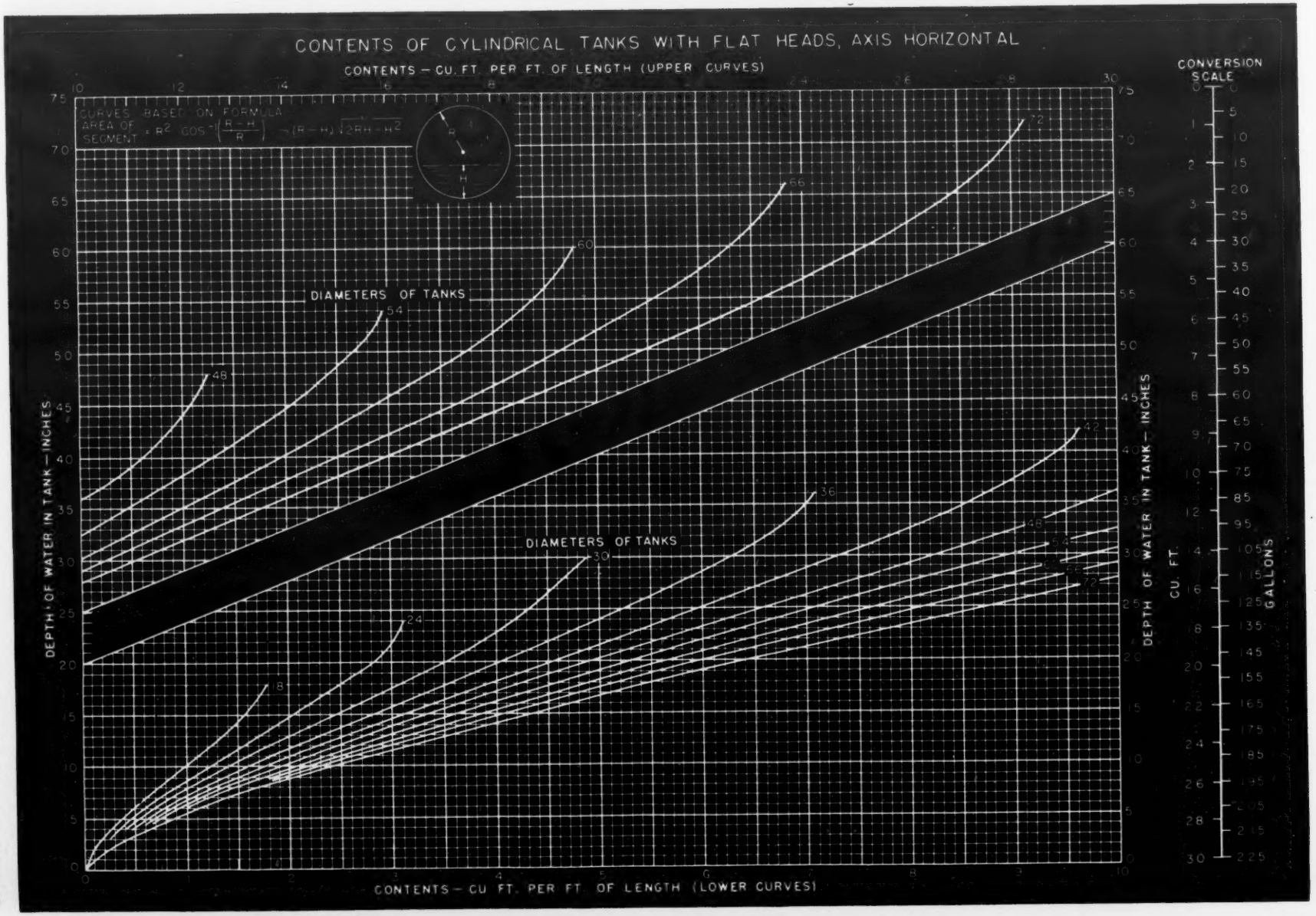
THE QUERY of C. H. T. is not as specific in its terminology as might be desired, and some of the terms stated do not agree.

However, assuming that he is operating a distillery and producing 7500 proof gallons of alcohol a day the following will apply:

1—A production of 7500 proof gallons a day will give a total production of carbon dioxide of, roughly, ten and a half tons. Of this he can reasonably expect to recover about eight tons as solid carbon dioxide under favorable conditions of operation. The sources of loss are the amount of CO_2 required to purge the system before turning into the scrubber, leakage losses at a number of stages in the system, and the CO_2 dissolved in the fermented mash as it leaves the fermenter.

2—Plant requirements will include two scrubbing towers about 5 ft. dia. by 30 ft. high which are packed with coke and in which the gas is washed in counter current with water; a drying tower, which is normally a tube condenser served with cold water in the tubes which serves to remove by chilling, part of the water vapor in the gas; a two or three stage condenser, with intercooling between stages to bring the gas to about 350 pounds to the square inch; a system for chemically removing the traces of organic compounds present; an alumina dryer; the last two systems must be in duplicate to allow for regeneration; an ammonia cooled condenser for liquefying the carbon dioxide; a suitable snow machine and press for forming the blocks and such auxiliary equipment as saws, conveyors and bagging tables for handling the finished cakes.

The cost of such a plant will depend to a large extent on how much is built by the user and the amount that can be obtained second hand. Several of the processes are covered by patent and this should receive close attention to avoid infringement. C. F.


CONTENTS OF CYLINDRICAL TANKS WITH FLAT HEADS, AXIS HORIZONTAL
CONTENTS – CU. FT. PER FT. OF LENGTH (UPPER CURVES)
CURVES BASED ON FORMULA
AREA OF SEGMENT = R² COS⁻¹((R−H)/R) − (R−H)√(2RH−H²)
DIAMETERS OF TANKS
72
66
60
54
48
42
36
30
24
18
DIAMETERS OF TANKS
DEPTH OF WATER IN TANK – INCHES
CONTENTS – CU FT. PER FT. OF LENGTH (LOWER CURVES)
DEPTH OF WATER IN TANK – INCHES
CONVERSION SCALE
CU. FT.
GALLONS

Industrial Plants purchasing electric power from electric utility systems will find it to advantage to make careful studies of the rate schedules from time to time as the load and demand changes. The case cited by the author is typical of the savings that may be made by such study. It is an actual case which arose in an automobile plant that came up in the experience of the author.

RATE ANALYSIS REDUCES POWER COSTS

By JULIUS B. LOME
Analysis Engineer
H. S. Tolchard & Associates, Jackson, Mich.

THE KNOWELDGE of the various provisions, "breaking points," and minor or major clauses of electric rates is highly important to the plant managers and plant superintendents. When rates are designed the Utility must take into consideration many factors in order to get a return on its investment and from these factors an average rate is made. At times special cases arise and utilities modify the rate to fit a certain specific case. As rates must be available to any one of the Utility's customers, if these customers qualify, this rate is naturally published.

In the paragraphs that follow we wish to relate a case in which a condition arose, which if not discovered in time would have meant an excessive investment with a small return. It was the discovery of the "breaking point of the rate" that prevented this.

An automobile parts manufacturer in one of the larger cities in Michigan was purchasing power and light from the local utility on a primary rate with the demand measured in kilowatts.

The rate on which power was purchased was as follows:

First 200 kw. of demand per month at $2.50 per kw.
Next 800 kw. of demand per month at 2.00 per kw.

There were other subdivisions of the demand charge but inasmuch as they do not have any bearing on this case we omit them here.

The energy charge was as follows:

First 100 hr. per kw. of demand at 1.1c per kw-hr.
Next 100 hr. per kw. of demand at 1.0c per kw-hr.
Over 200 hr. per kw. of demand at 0.8c per kw-hr.

The average bill of this manufacturing concern was therefore as follows:

DEMAND CHARGE:

First 200 kw. of demand at $2.50 per kw.	$ 500.00
Next 550 kw. of demand at 2.00 per kw.	1100.00
Total 750 kw.	$1600.00

ENERGY CHARGE:

First 100 hr. per kw. demand of 75,000 kw-hr. at 1.1c	$ 825.00
Next 100 hr. per kw. demand or 75,000 kw-hr. at 1c	750.00
Remaining 25,000 kw-hr. at 0.8c per kw-hr.	200.00
	$1775.00
Total bill	$3375.00

There was another rate available for this company which was based on a kv-a. demand.

For demand below 1000 kv-a. this rate was a follows:

DEMAND CHARGE:

First 100 kv-a. of demand at $2.00 per kv-a.
Next 100 kv-a. of demand at 1.80 per kv-a.
Over 200 kv-a. of demand at 1.45 per kv-a.

ENERGY CHARGE:

First 100 hr. of demand at 1.1c per kw-hr.
Next 100 hr. of demand at 1.0c per kw-hr.
Over 200 hr. of demand at 0.8c per kw-hr.

For demands over 1000 kv-a. the demand charge was the same up to 20,000 kv-a. of demand.

The energy, however, was as follows:

First 40 hr. of demand at 0.8c per kw-hr.
Next 120 hr. of demand at 0.7c per kw-hr.
Over 160 hr. of demand at 0.6c per kw-hr.

The power-factor of this company was around 55 per cent. The local utility called on several occasions the attention of this company to the savings possibility of the kv-a. demand rate.

The utility engineers pointed out that if this company would correct their power-factor by means of capacitors to 95 per cent then the demand would be around 790 kv-a. and this would render their average monthly bill as follows:

First 100 kv-a. of demand at	$2.00 per kv-a.	$ 200.00
Next 100 kv-a. of demand at	1.80 per kv-a.	180.00
Remaining 590 kv-a. of demand at	1.45 per kv-a.	852.50
Total 790 kv-a.		$1232.50

ENERGY CHARGE:

First 79,000 kw-hr. at 1.1c per kw-hr.....	$ 869.00
Next 79,000 kw-hr. at 1.0c per kw-hr.....	790.00
Remaining 17,000 kw-hr. at 0.8c per kw-hr.....	136.00
Total 175,000 kw-hr.	$1795.00
Total bill	$3027.50

This compared with their actual bill meant a monthly saving of $3375.00 less $3027.50 or approximately $350.00 per month.

To bring this saving about it necessitated the installation of about 870 kv-a. in capacitors at an approximate cost of $8000.00. While this is quite a lucrative investment the company put off for some time to make this investment and take advantage of the saving.

When the company finally decided to make this investment it deemed it necessary to have some outside advice. We were called in. Naturally, after reading the report of recommendations of the utility company we were quite ready to agree. However, before making our final recommendation we thought it advisable to study all angles of the rate.

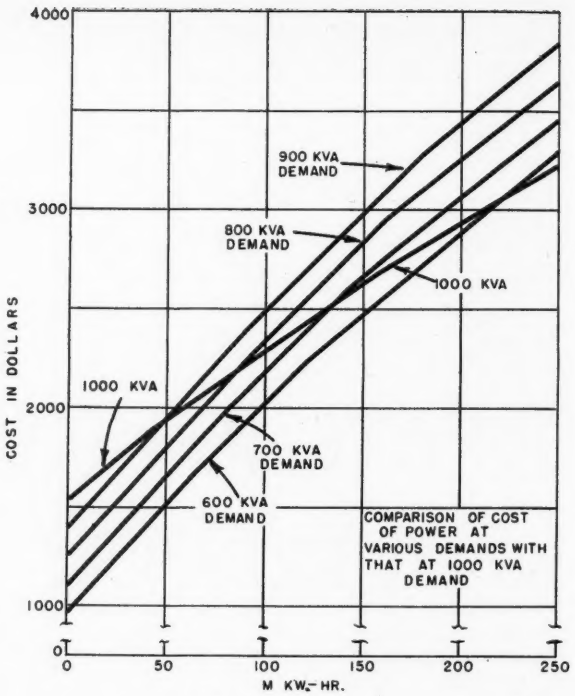
After completing our study, we could no longer agree with the utility's report, and we recommended that the power-factor be only corrected to 75 per cent, and thus reduce the investment in half and on top of that increase the saving, in spite of how parodoxical the latter may sound.

By correcting the power-actor to only 75 per cent the kv-a. demand would be 1000 kv-a. With a 1000 kv-a. demand the company would have been entitled to the energy charge that goes with a demand of 1000 kv-a. and over.

The monthly charge would have been as follows:

DEMAND CHARGE:

First 100 kv-a. of demand at	$2.00 per kv-a.	$200.00
Next 100 kv-a. of demand at	1.80 per kv-a.	180.00
Remaining 800 kv-a. of demand at	1.45 per kv-a.	1160.00
		$1540.00



Comparison of cost of power at various demands with that of 1000 kv-a. demand

ENERGY CHARGE:

First	40,000 kw-hr. at 0.8c per kw-hr....	$320.00
Next	120,000 kw-hr. at 0.7c per kw-hr.....	840.00
Remaining	15,000 kw-hr. at 0.6c per kw-hr.....	90.00
		$1250.00
Total monthly cost.....		$2790.00

In other words, by increasing the demand, the company was saving additional $237.50 ($3027.50 less $2790.00) per month. Besides this saving, to correct a 750 kw. demand at 55 per cent to 75 per cent necessitated only 410 kv-a. of capacitors at an approximate cost of only $3800.00.

It will be of interest to note that since the foregoing was brought to light, the local utility changed its method of billing for their larger customers. All those customers who had a demand of less than 1000 kv-a., however, whose cost would have been lower if they had, had a 1000 kv-a. demand, were billed as if they actually had a 1000 kv-a. The accompanying graph shows the breaking point of the rate at various demands and consumptions as compared with the same consumption at 1000 kv-a. demand.

PURCHASE of carrier-current communication equipment for linking the TVA dams at Wilson and Hiwassee with the existing circuits of the TVA system has been announced by the Radio Division of the Westinghouse Electric & Manufacturing Company. This equipment, specified for early 1940 delivery, will consist of two standard Westinghouse transmitter-receiver units of 150 watts power with the necessary coupling capacitors and line tuning units for one equipment.

Thermal Insulation for Air Conditioning

Insulation is an important item on air conditioning jobs. It must be sufficiently thick to accomplish the desired result, have the proper characteristics for the application and be installed correctly.

By
J. F. STONE*

BASICALLY, insulation against heat flow is an accessory to air conditioning equipment, like a heat economizer or air preheater to a steam generating system. It is used to: 1, Reduce heat entry into conditioned spaces. 2, Reduce heat flow into ducts carrying conditioned air. 3, Minimize heat pick-up by refrigerated pipes. 4, Prevent condensation on cold surfaces of pipes or equipment.

At certain seasons it also serves to keep heat within places where it is wanted. In all of these uses except No. 4, the main objective is greater economy of operation. A secondary objective is greater ease and accuracy of control.

For any given set of conditions there is a most economical thickness of insulation, which is that thickness at which the sum of the cost of refrigeration (or heat) and the cost of the insulation, is a minimum.

Generally it is not worth while to go through so detailed a calculation to determine economical thickness as in any case it is necessary to use the nearest commercial thickness of the insulation chosen. For practical purposes, tables are available to give thickness satisfactory on most jobs (see the A. S. H. & V. E. Guide).

Ducts and Equipment

Frequently, the controlling factor in the decision as to proper thickness of duct and equipment insulation is that thickness necessary to vent condensation on the surface of the insulation. To answer this question it is necessary to know:

a. The temperature of the duct. Generally close enough if considered same as the air inside.
b. Temperature of air surrounding duct.
c. Maximum relative humidity expected at b or maximum wet bulb at b.
d. Conductivity of proposed insulation and conductance of any other materials involved.

*Staff Manager, Johns-Manville Co., New York, N. Y. This article is part of a lecture prepared in connection with the Westinghouse air conditioning school.

Temperature drop across a series of resistances is directly proportional to the resistance encountered. For example consider a duct carrying air at 50 deg. F. and an outside temperature of 80 deg. F., and 1 in. of insulation having a conductivity of 0.31.

Resistance is the reciprocal of conductance or numercially, thickness divided by conductivity, in this case for the 1 in. insulation, 1 divided 0.31 or 3.23. Assuming surface resistance as indicated below, the total resistance to heat flow is:

Resistance of air film at surface of insulation	0.6
Resistance of insulation	3.23
Resistance of air film, inside of duct	.27
Total Resistance	4.1

Total temperature drop is 80 — 50 = 30 deg. F. Since the temperature drop through any section is proportional to the corresponding resistance, the temperature at the surface is (0.6 ÷ 4.1) 30 or 4.4 deg. F. below the air temperature or 80 — 4.4 = 75.6.

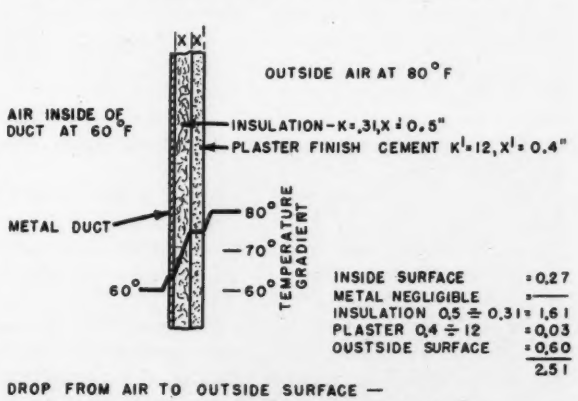


Fig. 1. The total resistance to heat flow can be determined by adding the individual resistances as shown. Resistance is the reciprocal of conductance

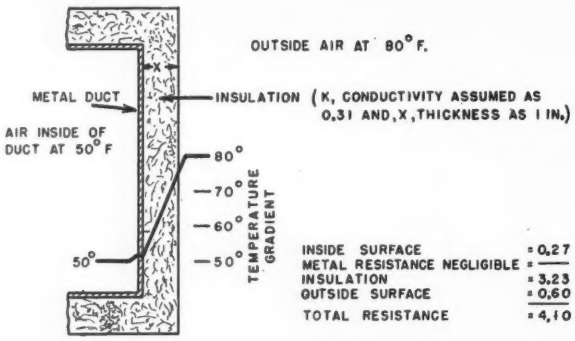

OUTSIDE AIR AT 80° F.
METAL DUCT
INSULATION (K, CONDUCTIVITY ASSUMED AS 0.31 AND, X, THICKNESS AS 1 IN.)
AIR INSIDE OF DUCT AT 50° F
80°
70°
60°
50°
TEMPERATURE GRADIENT
50°
INSIDE SURFACE = 0.27
METAL RESISTANCE NEGLIGIBLE = —
INSULATION = 3.23
OUTSIDE SURFACE = 0.60
TOTAL RESISTANCE = 4.10
DROP FROM OUTSIDE AIR TO SURFACE OF INSULATION IS -
(0.60 ÷ 4.10) X 30 = 4.4°F. SURFACE = 80 - 4.4 = 75.6°F.

Fig. 2. When two layers of insulating material is applied the procedure is the same. The resistance of any layer is the thickness divided by the conductivity

From a psychrometric chart we find that 80 deg. F. dry bulb air has a dew point of 75 deg. F. at a relative humidity of about 84 per cent (wet bulb 76.3 deg. F.). Thus the calculated temperature drop of 4.4 deg. F. from the air to the insulation is not sufficient to cause condensation.

For most cases 1 in. thick material is ample for a temperature difference of 30 deg. F. and ½ in. is sufficient for most cases when the temperature difference is 20 deg. F. If the temperature difference reaches 40 deg. F., 1½ in. insulation gives a temperature drop of 4.1 deg. to the surface, and at a 50 deg. F. difference the drop from surrounding air to the surface is just scant of 4 deg. when 2 in. insulation is used.

From the foregoing it may be stated that ½ in. of insulation of a conductivity approximating 0.30 is required at a temperature difference of 20 deg. F., and ½ in. added to the thickness for each 10 deg. F. increase in overall temperature difference, if there is to be no sweating at a relative humidity slightly over 80 per cent.

It should be borne in mind that there ought to be some factor of safety allowed in such calculations. Consequently either use a conductivity higher than the laboratory value for an insulation or assume that the maximum relative humidity may go higher than you expect. Very few insulations have as low a conductivity under service conditions as when tested in the laboratory due to the picking up of moisture from the air. This pick-up increases the conductivity from ten to fifteen or more percent depending on the material. In general it is wise to assume the service conductivity will be at least 10 percent above the laboratory value.

Calculations above were based on a service conductivity of 0.31. If it is desired to maintain the resistance shown, the thickness required will vary directly with the conductivity of the material above or below that value.

In the selection of materials for insulation of air-conditioning equipment, the choice is confined within a narrow field. The various parts of the equipment such as piping, fittings, ducts, etc., require built-up or moulded shapes. The conditions of operation require definite characteristics.

On the other hand, the selection of a suitable material for the insulation of buildings, whether homes or commercial structures, is a distinct problem to the builder, owner, or consultant. In the A. S. H. & V. E. Guide are listed many materials classed as building insulation and, in most cases, designated by trade names. Weights and conductivities are given, together with a brief description of physical characteristics or raw material content. More elaborate information on all of these materials is set forth in the various manufacturers' catalogues. With such an array of materials and claims of efficiency, the average man is usually at a loss to make a decision.

Conductivities of materials are the results of the laboratory testing of a small sample of the material, usually of 8 by 12 by 12 in. dimensions by the guarded hot plate method. The material is clamped between a hot and cold plate and, by means of measurement of electrical input to the hot plate, the flow of heat through the material is computed. The result is given as the B.t.u. passing through one square foot of the material per hour, per one degree temperature difference, per one inch thickness and, further, as a function of a definite mean temperature.

Thermal efficiency, however, is only one of several requirements necessary for a satisfactory commercial insulation. The insulation must have other properties among which are the following:

Physical and chemical stability for the material must not easily disintegrate, either physically or chemically. It should not be susceptible to deterioration by moisture, air, vermin or surrounding materials. Neither should it attack other materials.

Structural strength is needed, for the material must be capable of remaining in place without settlement, for the life of the structure.

Adaptability is advisable, for the material should be easy to apply and of such form as to be suitable for use in whatever type or shape of space it is to be put. Installation should be able to be made with minimum disturbance to the building structure or the occupant. This is especially important in private dwellings already occupied.

Total cost should receive maximum attention. It is the summation of the initial cost, operating cost and depreciation cost. This latter item should be merely a theoretical figure, as a truly satisfactory material would not deteriorate. However, obsolescence of the building and with it, the insulation, has to be considered, whether it is called depreciation or something else.

Workmanship

In closing, it seems appropriate to issue a word of warning against exaggerated claims either as to the efficiency of an insulation or its adaptability to a multitude of uses. Different types of service usually demand different characteristics and there is no such thing as a universal insulation. Also, and particularly in respect to refrigeration insulation, workmanship is vital. The best insulation ever manufactured will not give satisfactory service if badly applied. Where cold surfaces have to be covered it is imperative that penetration of moisture be reduced to an absolute minimum. This means materials that can be properly sealed and applicators who will do it.

Reducing Flyash Emission

This article is based largely on a paper presented by the author before the S.P.A. Milwaukee Convention, a comprehensive review of the simple and proprietary devices available for combating this ever increasing nuisance. In this article the proprietary devices have been largely eliminated to form what may be called an introduction to the science of dust collecting. The simple devices described are in general applicable to the smaller plant for the elimination of the heavier particles.

By J. F. BARKLEY

Supervising Engineer, Fuel Economy Service, Bureau of Mines, U. S. Department of the Interior, Washington, D. C.

FLYASH PROBLEMS start with the necessity of knowing what flyash really is, what plants really create it, and how much is being created. Flyash in this connection may be defined as all solid particles emitted to the atmosphere resulting from the combustion of fuel.

Much can be learned about flyash by studying samples with a strong magnifying glass, or preferably, with a high power microscope. As an example, Fig. 1A is a photomicrograph of an underfeed stoker flyash weighing 23.7 lb. per cu. ft. which passed a baffle type cinder catcher and was caught by a Cottrell precipitator. Figure 1B shows a similar flyash made at a higher stoker rating, weighing 36.2 lb. per cu. ft. The lighter ash contains more light unconsolidated ash than the heavier.

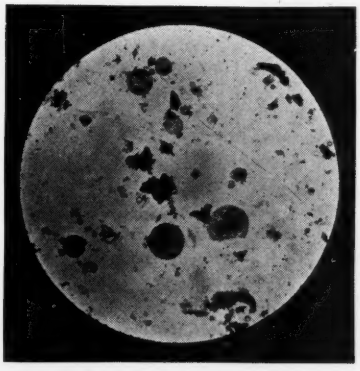
In both instances some of the ash has been fused to a glass which is indicated by the spherical particles resembling marbles; the heavier dust, however, contains more and larger spheres. Under the conditions of the faster burning and higher air pressures occurring at the higher burning rates, more of the larger fused spheres reached the precipitator.

Sizing of particles leaving the stack is of great importance from a nuisance standpoint. Just what minmum size a particle must be to be out of the nuisance range is controversial. It is stated by some that 20 microns is a good dividing point; that particles below this size are within the size range of the dust particles that circulate normally in the atmosphere.

The height of the stack and the wind velocity also are factors. It is possible with mathematics to theorize as to when and where a given particle will fall. Possibly the original formula for these studies was developed by Stokes. Such theorizing is helpful in developing general ideas.

It shows that each particle falls at a constant velocity, this velocity depending on its size and specific gravity; for example, the larger particles fall most rapidly thus landing nearer the stack in a relatively small circular area, the lighter particles farther out in a much larger circular area. A 40-micron particle falls nearly twice as fast as a 30-micron particle, and about four times as fast as a 20-micron particle. A 10-mile wind would carry the particle twice as far as a 5-mile wind. It has been calculated that a 20-micron particle leaving a 200-ft. stack in a 5-mile per hour wind would fall about 3.5 miles away; in a 10-mile wind about 7 miles away.

To decide what amount or sizing of flyash from a stack creates a nuisance, how to legislate against it, and how to determine the amount of sizing of the ash are all difficult. A "nuisance" depends on the varying ideas of humanity which do not give an absolute standard toward which to work. People did not become particularly excited over sand and dust particles until the many paved roads caused much of it to disappear. One city considers that the best solution is merely to state that "fly-ash nuisance" from a stack will not be permitted, leaving the decision as to what is a nuisance to the abatement engineer. Another city establishes the limitation on an exact basis—400 grains per 1000 cu. ft. of combustion gases. Methods of determining the amount of flyash being emitted are quite costly, requiring much time and equipment. They appear practical for large installations only. It is usually necessary to measure the amount of gases flowing which involves the determination of the many velocities over a given cross-sectional area of the stack. Where a sample is taken, it is necessary to draw out the gases at the same speed



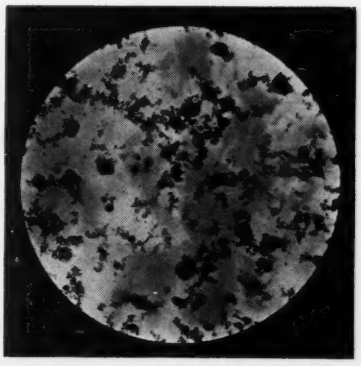


Fig. 1. Photomicrographs of flyash. Left, a light flue dust weighing 23.7 lb. per cu. ft., and right, a heavier dust weighing 36.2 lb. per cu. ft. with less light unconsolidated ash and larger fused particles

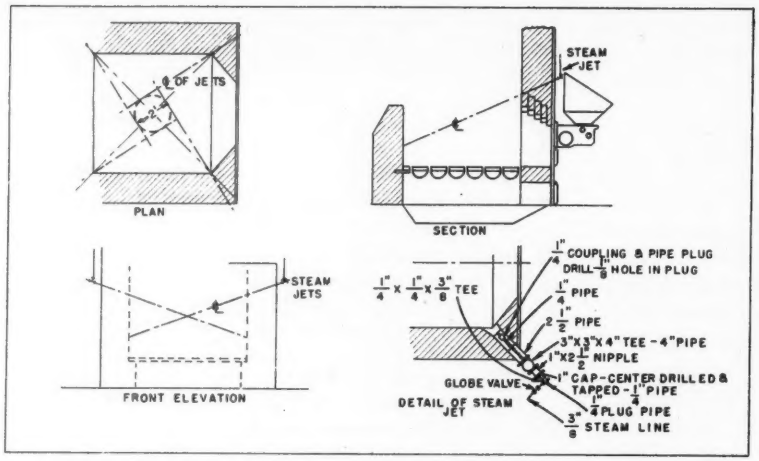


Fig. 2. Furnace fitted with four steam jets and details of a steam jet made from standard pipe fittings

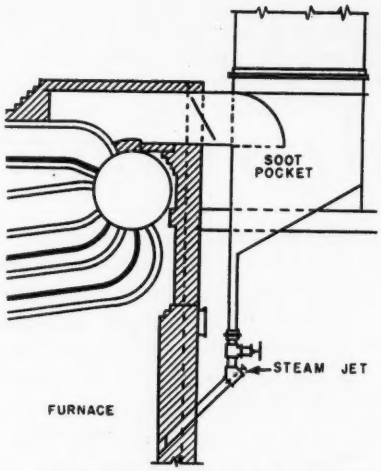


Fig. 3. A simple method of eliminating heavier particles

at which they are flowing in the stack. Different ash flow occurs at different points in a cross-sectional area.

Probably the simplest, most practical scheme to date to determine the amount of flyash is to weigh, for a chosen period of time, the coal and all refuse or ashes obtainable from the ash pit, any collecting hoppers, any places available on the way to the stack and the base of the stack. From the ash analysis of the coal and the total coal weight, the amount of ash put into the fuel-burning equipment can be calculated.

An average ash analysis of all the refuse and its total weight would give the amount of actual ash caught. The difference in these weights represents the ash that is considered to have gone out the stack. With this ash went combustible material that can be assumed to be in about the same ratio as shown by the analysis of the refuse caught, say, at the base of the stack. The accuracy of such a method is probably not less than that of other methods particularly over a reasonable length of time of test.

The following figures show various methods of separating flyash from the product of combustion. In the dry separators, the principle of separation is based on the difference in specific gravity of the fly ash and the gases. This means, in general, that an ash particle falls by gravity in the gases; in still and horizontally moving gases, certain time would be required to drop a given distance; in gases having a vertical movement, its velocity of fall would be checked even to reversal and movement upward with the gases.

If the velocity of horizontally moving gases is lowered by an increase in the area of the carrying duct, the particle has more time to drop to the bottom of the duct; if the velocity of vertically moving gases is lowered by an increase in area, the particle does not have as great a force preventing its downward movement. This points to the desirability of low gas velocities in the stack.

If the particle strikes a baffle or a filter, its forward movement is checked. Upon a change of direction of flow of the gases, the heavier ash particle is slower to respond and, relative to the gases, tends to continue its original direction. Advantage of this fact is taken in centrifugal separation in which the ash particles swing to the outside of a cyclone-type or centrifugal-fan-type separator.

Much work has been done on the development of wet types of flyash separating equipment. This development started many years ago; possibly it originated with the use of simple type sprays in the stack. Where it is necessary to open the door at the base of a stack to clean out flyash accumulations, the use of a spray will

[1]For a somewhat similar arrangement at the entrance to an induced draft fan see the article on the Mac Sim Bar Paper Co., Power Plant Engineering, p. 781, December 1938 and p. 463, July 1939.

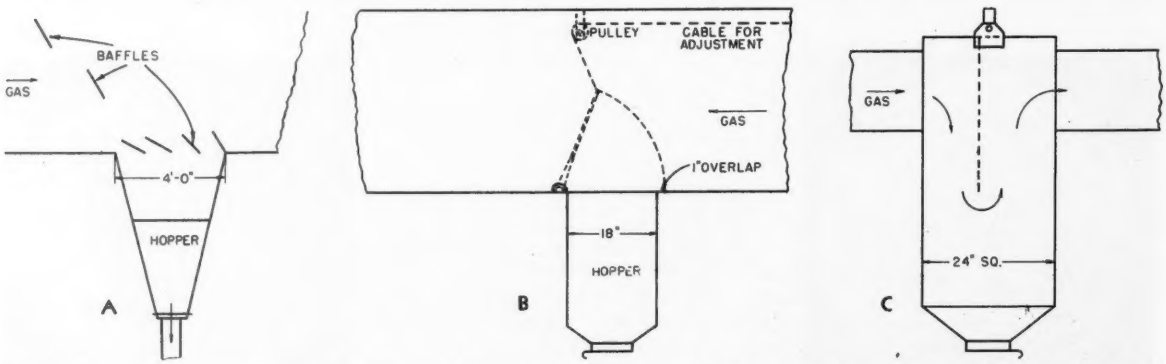


Fig. 4. Three different arrangements of baffles and skimmers used to increase the effectiveness of soot pockets for the elimination of heavier particles

be found very helpful, since dry flyash usually will be lifted by the air entering the door opening.

In general, the flyash from stokers of the underfeed or the spreader type is easier to separate from the gases than that from pulverized fuel. The percentage of the mineral ash in the fuel that becomes part of the flyash leaving the furnace varies widely with the type of equipment and type and size of fuel. Studies have shown from 5 to 30 per cent of the ash of the coal leaving the furnace for underfeeds, from 20 to 40 per cent for spreader stokers, and from 50 to 85 per cent for pulverized fuel equipment. Accompanying this ash, combustible material was found in various ratios from 10 per cent to as high as 85 per cent.

The rating at which the fuel burning equipment operates is an important factor. For example, on one underfeed stoker installation, increasing the fuel burned per square foot of grate area about three-fourths, or from 23.0 to 40.5 lb., raised the amount of flyash produced about 3.8 times per lb. of coal. The actual weight of flyash leaving the boiler per hour increased 6.8 times. Where flyash is permitted to accumulate too much in one place, such as along the bottom of the breeching, it may suddenly lift all at once and create an immediate nuisance. Keeping all passages clean is a great help.

Properly placed steam jets will knock down an appreciable amount of flyash. It is possible some of the ash particles are united to form heavier particles, thus tending toward easier separation. Figure 2 shows a furnace fitted with four jets. The jets are tilted downward and create a circular turbulence in the center of the furnace, each jet spinning the gases in the same circular direction.

They may also be arranged so that two of the jets, one on each side of the furnace, tend to spin the gases in the opposite direction to the other two jets. Frequently two jets only are used, one at each front corner of the furnace. A typical steam jet is shown in the detail. It is desirable to connect the air inlet to the jet to the wind-box of the stoker, to air channels in the furnace or bridge wall, etc. Such air inlets prevent noise.

Figure 3 shows a simple scheme for eliminating heavier ash particles by causing a downward flow of the gases and ash just after leaving the boiler damper. The flue gases then rise at lowered velocity in a much larger cross-sectional area. The flyash is returned as shown for reburning in the furnace.

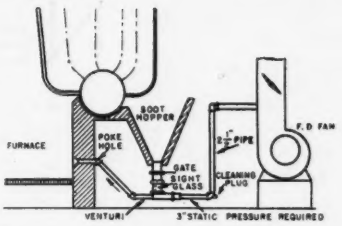


Fig. 6. Another method of return utilizing the main forced draft fan for the return of flyash

Figure 4A shows a baffle arrangement in a breeching to throw ash particles into the hopper mounted on the bottom of the breeching. Figure 4B shows a somewhat similar scheme in which a baffle is hinged and positioned by manual adjustment. This trap placed in the breeching of a small boiler with an underfeed stoker caught about 3 cu. ft. of flyash per ton of coal fired. Figure 4C shows a vertical single baffle trap with hopper.

One important means of lowering the amount of flyash is to return it to the furnace for reburning. In general, it should be returned into a hot part of the furnace, or where there is considerable flame. In the installation shown in Fig. 7 the flyash caught at the last pass of the boiler is continuously returned by steam jet to the furnace, thus reducing its amount.

Figure 6 shows a scheme for returning flyash to the furnace from the boiler passes and from a flyash separating fan. A small auxiliary forced-draft fan is used instead of a steam jet. Figure 5 shows the application of air directly from the discharge side of a forced-draft fan to return flyash to the furnace.

The problem of choice of flyash separating equipment involves separating efficiency, draft losses, space requirements and costs.

The range of efficiency based on total ash content of all size particles appears to be from 15 or 20 per cent up into the nineties. Rating figures can also be based on the efficiency in removing chosen size particles. Where it has not been practical to consider the higher cost, more efficient equipment, however desirable, much improvement has resulted and complaints have been stopped in certain cases by the careful choice of lower cost equipment.

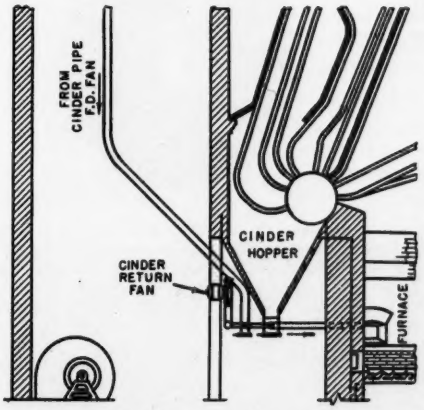


Fig. 5. Flyash from soot hoppers and dust collectors may be returned to the furnace by means of a small auxiliary forced draft fan

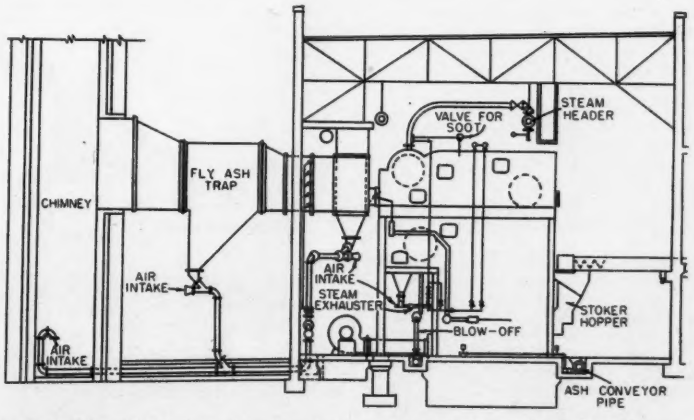


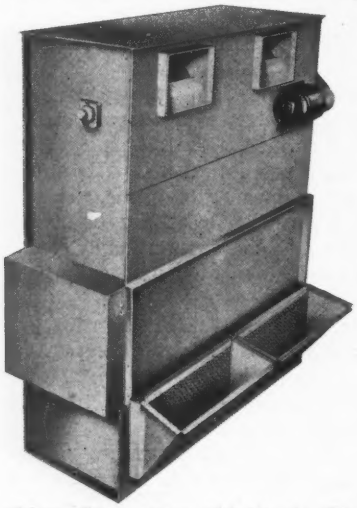
Fig. 7. Typical layout showing ash system for removal of flyash caught at the last pass of the boiler, the collector and stack with the return from the soot pocket at the intermediate pass of the boiler, direct to the furnace by means of a steam jet

New Equipment

Information that you desire about any equipment will be gladly furnished without obligation. WRITE POWER PLANT ENGINEERING.

Evaporative Cooler

THE TRANE EVAPORATION COOLER, made by The Trane Co., La Crosse, Wis., has been particularly designed to cool fluids in a closed system. This method eliminates the possibility of contaminating the liquid being cooled and affords cooling

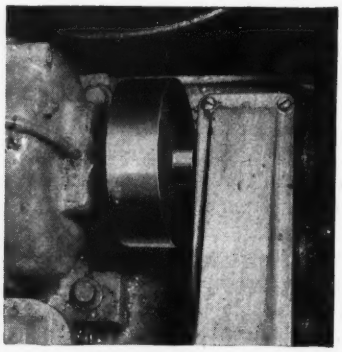


without direct contact with the air. The use of the Trane evaporative cooler for Diesel engine cooling prevents scale formation in the jackets of engines. Other uses are: cooling dehumidifying liquids, cooling transformer oil; and cooling quenching oil.

Automatic Centrifugal Clutch

DAWES EQUIPMENT, INC., 2280 Penobscot Bldg., Detroit, Mich., has developed a new, positive acting, automatic centrifugal clutch consisting of two main parts—the housing drum, or driven member, and the expansion body or driving member. A steel cover-plate held in position by means of a lock ring, seals the clutch mechanism against dust. The expansion body consists of six metal segments interconnected by tension springs and operating on individual posts extending radially from the driving hub.

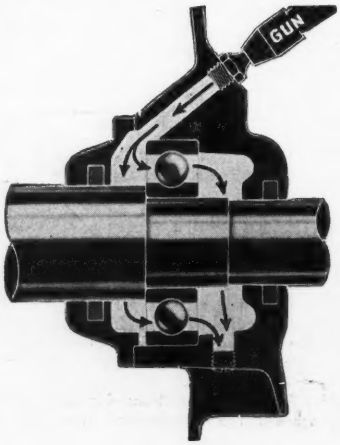
When at rest the clutch is disengaged. It can be built to engage smoothly at any desired speed and for any horsepower. Most industrial requirements are served by six standard sizes over a range of 1 in. up to and including 2⅜ in. diameter shaft for horsepowers between 0 and 125. The horsepower transmitted increases directly as the cube of the speed. The "free wheeling" effect cushions shocks, thus cutting down starting demand loads and so saving on power costs.



This cushioning of shocks eliminates one of the greatest causes of wear in driven equipment. It functions both as a clutch and a flexible coupling on direct drives, and it requires only about the same amount of space as a flexible coupling.

New Lubricating System for Motors

THE accompanying illustrations shows the U. S. Lubriflush system of lubricating motor bearings which has been recently developed by U. S. Motors Inc., Los Angeles, Cal. After electrical motors are operated for several months, it is desirable to purge the bearing chamber of the old lubricant. In the orthodox design of bearing chambers, no provision is made for the escape of old lubricant. When new lubricant is applied to the bearings, it mixes with the old grease. U. S. Motors engineers have devised a new method of lubrication known as Lubriflush, which is a distinct departure from the system that has been in vogue for many years. Through a duct leading from the outside of the motor, new lubricant is injected to the inner side of the bearing with a pressure gun. A drain is placed on the opposite side of the bearing underneath. As the new lubricant is injected, the old lubricant is forced out of the bearing and before the new lubricant reaches the drain exit it must first flush the entire bearing and chamber.



This method of bearing lubrication eliminates the evil results of sludgy, wornout lubricants. It provides a method of ejecting the old devitalized grease so that the bearing is replenished with clean lubricant throughout its retaining chamber. The grease fitting and drain plug are easily accessible. This method prevents the retention of sludgy substances and residue.

Application of the U. S. Lubriflush system to all U. S. Motors is now being effected.

Automatic "Telltale" Signals

EASILY attachable to all types of commercial or domestic installations, a new "telltale" device which automatically flashes a light signal when it is time to change or clean air-conditioning equipment filters has been put on the market by Simplex Controls, a division of the Herbusch Corp., St. Louis, Mo.

The accessory consists of a dual metal disc about 12 in. in diameter upon which is mounted a housing containing the contact device which flashes the lamp signal when excess static pressure is built up in the unit between the filters and the blower. It is attached by a simple ½-in. threaded nipple and locking nut at the conditioner unit. While the Electric Filter Watchman is fac-

tory-set to signal when pressure is a normal 25 S.P., it is possible to vary the setting so that the "telltale" signal will take place at any predetermined static pressure. The attachment is operated on a mechanical principle which utilizes the accurately calibrated velocity of the conditioning equipment. Its rugged and simple moving parts should render a lifetime of service without failure, free from repairs or replacements, except for normal replacement of the electric bulb.

USE THESE VALVES-
...lots of them!

THERE are many places where Edward forged body steel gage valves are useful. Although made to precision and quality standards, prices are astonishingly cheap. That's because they are so useful, in so many places, that the demand warrants quantity production with resultant low cost. Various fine steels are available for a variety of services. Walls are made heavy in proportion to internal passages to justify use on instrument lines at pressures up to 4,000 lb. Carefully cut taper threads of generous length make safe body-bonnet joints. The new knobbed handwheels give improved leverage and grip. For viscid fluids, at slightly lower pressures, there is the Fig. 150 companion line of straight through valves. Gage valve is Fig. 152. Try a few of each!

• • • •

THE EDWARD VALVE & MFG. CO., INC.
EAST CHICAGO INDIANA

MADE IN SIZES ⅛" to 1"

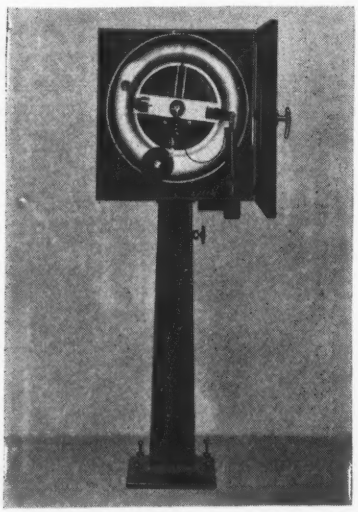
EDWARD Valves

STOP • CHECK • BLOW-OFF • NON-RETURN
FEED-LINE • RELIEF • BLEEDER LINE • ETC.

East Chicago, Indiana

Ring Balance Meter Body

THE NEW ring-balance meter body of the Republic Flow Meters Co., 2224 Diversey Parkway, Chicago, Ill., is designed to measure flow of low-pressure gas or air. It is built to give a full scale reading on differentials as low as 2 in. of water



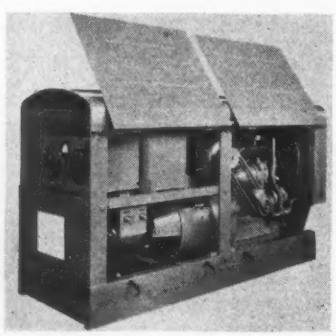
at static pressures up to 20 lb. per sq. in. Gas is confined to the ringbalance and does not come in contact with measuring elements, so that dirty and corrosive gases cannot affect its operation. A changeable calibrating device is provided to change scale ranges. In operation, differential pressure from a primary element in the gas line is impressed on a 22½ in. O. D. welded steel tilting ring, causing it to move a standard resistance scale in a mercury well. This scale movement produces electrical resistance changes proportional to the gas flow which actuate standard Republic instruments, indicator, recorder and integrator—at a remote point.

Diesel Engine-Driven Arc Welder

THIS 300-ampere welder, which is equipped with gasoline engine starting, simplifies the use of Diesel power in dependability of starting, simplicity, weight and cost, as well as in operating speed.

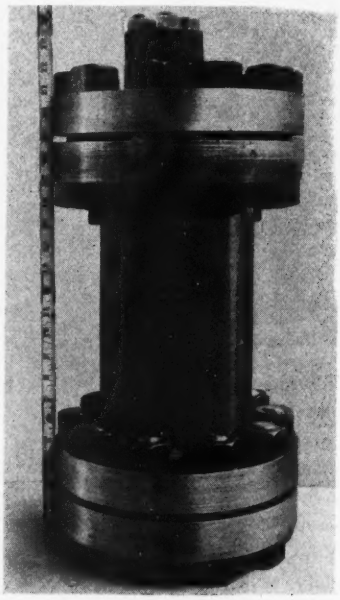
Small auxiliary engine is mounted above the Diesel and is started by means of a hand crank, a belt drive and clutch connecting the starting engine to the Diesel. Cooling system of the starting engine is connected into that of the Diesel to warm up the Diesel by allowing the heated water to circulate through both systems.

Generator used on the new welder is the 300 ampere Shield Arc SAE unit, with dual continuous control. Frame of the generator is attached directly to the Diesel engine bell housing, the generator shaft being connected to the engine flywheel by a flexible coupling. Mounting of the unit on a substantial channel frame.



Extreme Pressure Trap

WHAT is believed to be one of the highest pressure traps in the world has just been delivered to the U. S. Bureau of Mines, by The Strong, Carlisle & Hammond Co., Cleveland, O. This specially built trap will discharge liquid

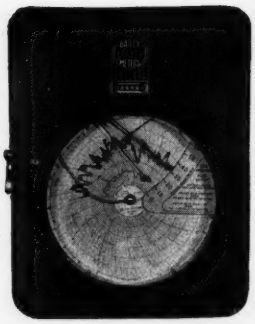


products obtained by the hydrogenation of coal, from 5000 lb. to atmospheric pressure. Suitable metals had to be selected for the trap body to resist this extreme pressure and the effect of ammonia and hydrogen sulphide in the liquid. The valve and seat of this super trap, are of Anum Metl.

Meter Restyling

BAILEY METER CO., Cleveland, Ohio, has restyled its complete line of meters for power plants and industrial processes. In restyling, sturdy construction features and other features used in the former meter casings were adopted for the new meters. The result is a meter basically the same in appearance as those meters now in service essential to maintaining uniformity where redesigned meters are added to existing installations.

Several mechanical improvements have also been made. Durability has been increased by a steel ring welded to the meter casing which also serves as a support for a new piano type hinged door. The door closes upon a synthetic sponge



gasket which has been designed to give complete contact against the inner surface of the door, thereby sealing the sensitive meter parts from moisture and dust. A narrow tray at the top of the meter casing prevents dust from falling into the meter when the door is opened.

Only the information necessary for reading of the chart record is now in sight. It is shown through the glass window of the meter. On the Bailey Boiler Meter, information is given on a plastic molded scale which indicates the rate of steam flow from the boiler and reminds operators how to constantly secure maximum economy by use of the meter.

On other meters identification of the factor recorded by each pen is given on a small metal plate inside the glass window at the bottom of the chart. As in the Boiler Meter a distinctive color is used for each record. Additional engineering information for authorized persons is available on the inside of the door.

Transparent Gage Cover

ASHCROFT American Gage Div. of Manning, Maxwell & Moore, Inc., Bridgeport, Conn., announces a new development which eliminates breakage of glass fronts on indicating gages. This new development is made out of a non-breakable, transparent plastic in the form of a cover which threads onto the gage case and is called the Trans-

parent Gage Cover. It has a tensile strength of about 5000 lb. per sq. in. and a compression strength of about 15,000 lb. per sq. in. The Transparent Gage Cover, available on 4½ and 6 in. Phenol Case Duragages, open up the dial of the gage and makes it much easier to read. It also makes the case moisture-proof and dust-proof.

LESS TIME OUT

for Boiler Cleaning and Repairs

READ THESE REPORTS

Boiler on Line 13 Months!

AN INDICATION of results being obtained with Nalco service for softening plants is contained in a report received recently covering a boiler inspection: "Boiler on line 13 months and 2 days and no scale nor corrosion."

18 Months Continuous Service!

HERE is a report on Nalco external treating: "Yesterday this No. 4 boiler was inspected for the first time after 18 months continuous operation and was found in such good condition that it was placed on the line immediately.

2 Years Without Turbining Tubes!

A RECENT REPORT on plant using Nalco stabilizing and internal treatment reads: "They have run two years without turbining their boilers. Their make-up is 100%. Their feedlines and heater are absolutely clean."

IF YOU are interested in reducing the amount of outage commonly experienced with your boilers, we suggest that you investigate the records of plants using the Nalco System of Feedwater Treatment. We will be glad to give you names of users near you. Write NATIONAL ALUMINATE CORPORATION, 6224 W. 66th Place, Chicago, Ill.

NALCO SYSTEM

Inquiries other than domestic, *except those from U. S. Possessions, Canada and Mexico,* should be addressed to ALFLOC LTD., Bush House, Aldwych, London, W. C. 2, Eng. Canadian inquiries should be sent to ALUMINATE CHEMICALS LTD., 372 Bay St., Toronto, Ont.

Multiple Belt Drive

THE ACCOMPANYING photograph illustrates a development announced recently by U. S. Electrical Mfg. Co.—a multiple belt for Variable Speed Drive Motors. Speed changes on the unit are effected by turning the hand wheel which shifts the motor on the base and this moves the yoke which actuates the pulleys. A new lubrication system provides a thorough method of greasing the pulley sliding fits. A hollow section of shaft is constructed through the pulleys and the grease is ejected through orifices from the hollow section of the shaft to the sliding surfaces. The end of the motor shaft is also equipped with a grease fitting.

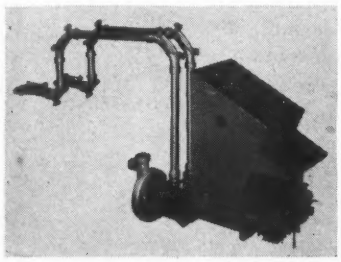
The belt may be tightened or loosened without shifting the entire base. This adjustment is made by working a set screw which turns the eccentric bushing located at the pivot point of the shifting yoke arm.

The sets of ways on the motor mounting base and the main unit base are very accurately machined; thus correct alinement is assured, and a rigid sliding support for the motor is attained.

Pneumatic Spreader Stoker

THE IRON FIREMAN MFG. CO. announces a new series of Pneumatic Spreader stokers, with provision for use of hot furnace gases for conveying coal.

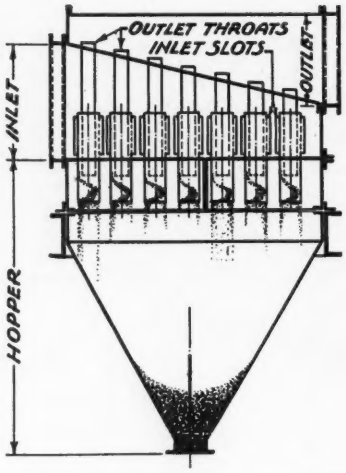
New high-pressure, radial-vane fans, with individual motor drives, are especially designed for handling combustion



gases. The hot gases expedite the conveying of damp coal, and heat the coal particles so that combustion is accelerated. Boiler-room air may also be used in the conveying system. Undergrate fan units may be located at front, side or rear of boiler. The stoker may be located anywhere in boiler room within a 20-ft. radius of boiler front, leaving firedoors clear. The stokers may be equipped with a variable speed drive and adjustable motor base that may be arranged for either manual adjustment, or for automatic adjustment through connection to the master regulator of any standard combustion-control system. The new stokers are built in both single-feed and dual-feed models, with capacities ranging up to 3200 lb. of coal per hr.

Tubular Dust Collector

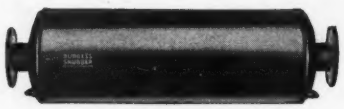
THE PRAT-DANIEL CORP., Port Chester, N. Y., announced the Thermix Tubular Dust Collector, a highly efficient centrifugal apparatus occupying a small amount of space which makes it desirable where space requirements are at a premium. The centrifugal apparatus is a series of steel tubes, each equipped with two slots in its upper half. Each slot has a directional vane



on the exterior of the tube. The lower half of the tube, which is a cylinder, extends into the dust hopper through a tube sheet. Entering the inlet plenum chamber, the gas passes through the slots in the tubes, rotating around a smaller central tube. The central tube extends to a point somewhat below the bottom of the slots in the outer tube, and upward to a tube sheet which forms the bottom of the outlet duct. The dust is precipitated against the sides of the outer tube and is carried down the walls of the tube into the hopper. The cleaned gas is evacuated through the smaller central tube to the outlet duct.

Snubbers

A NEW series known as the Burgess SDHC series Snubbers is announced by the Acoustic Division of Burgess Battery Co., Chicago, Ill. The new line of Snubbers covers a range of standard pipe sizes from 1 to 32 in. Both size and weight have been reduced by a unique rearrangement of the controlling

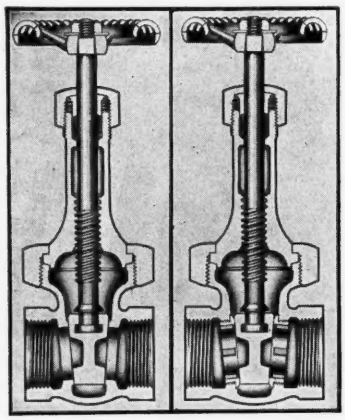


parts. All of the performance features of the original Snubber are included in the new Burgess SDHC series Snubbers.

Another change in the new design lies in the substitution of concentric connections for eccentric connections to facilitate installation. Sizes 1 to 4 in. are provided with nipple connections, while sizes 5 in. and larger are provided with flange connections.

Gate Valve

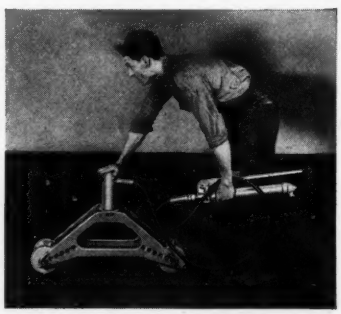
CRANE CO., 836 South Michigan Ave., Chicago, Ill., announces a new line of 200 lb. brass gate valves, made with wedge disc, union bonnet and rising stem. They are identified as No. 422 and No. 423 and are identical except for the body, No. 422 having seats cast integral with



the body and No. 423 having renewable body seat rings. No. 423 is regarded as ideal where severe operating conditions are best met with a renewable seat valve. The discs in both valves and the body seat rings in the No. 423 are made of Crane nickel alloy.

Pipe Bender

USING a 20-ton hydraulic unit and handling 7 sizes of pipe up to 4 in., the new model S-36 pipe bender is announced by the Blackhawk Mfg. Co., Milwaukee, Wis.



The hydraulic unit includes an all-directional ram, coupled to the bender by a high-pressure swiveled hose and is equipped with a hand pump. The unit may be disconnected and used with special attachments for pulling gears and pulleys.

Fig. 2125
Double Wedge Disc
Rising Stem

Fig. 2129
Single Wedge Disc
Non-rising Stem

LUNKENHEIMER
125 lb. S.P.
BRONZE GATE VALVES

These two valves offer more economical and satisfactory service on the numerous low-pressure applications around industrial plants.

Their advanced design provides unusual strength and ruggedness -- machining is to close tolerances -- materials exceed accepted standards. We invite direct comparison with any 125 lb. S.P. bronze gate valve you may now be using.

On your next order for 125 lb. S.P. bronze gate valves, specify Fig. 2125 for the Double Wedge Disc, Rising Stem type or Fig. 2129 for the Single Wedge Disc, Non-rising Stem type. You will profit from the excellent service you will get from these fine valves.

For detailed design and construction features write for circular 544.

ESTABLISHED 1862
THE LUNKENHEIMER CO.
"QUALITY"
CINCINNATI, OHIO, U. S. A.
NEW YORK CHICAGO
BOSTON PHILADELPHIA
EXPORT DEPT. 318-322 HUDSON ST., NEW YORK

CARRIED IN STOCK BY LUNKENHEIMER DISTRIBUTORS

Relay Protects Generators Against Motoring

A NEW DIRECTIONAL undervoltage relay for protecting generators against motoring is announced as Type GGP by the General Electric Co. The new relay combines the high sensitivity and the nonbouncing features of an induction-cup, polyphase, directional element with the accurate and adjustable timing of an induction-disk undervoltage element.

The undervoltage element of the relay is normally energized through contacts on the directional element. These remain closed unless there is a reversal of power when the generator starts motoring. If this occurs, the contacts open and de-energize the undervoltage ele-

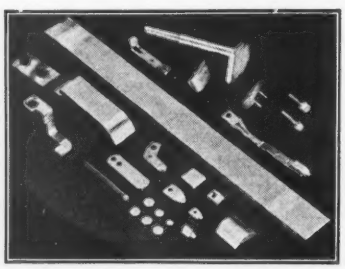
ment, which in turn closes its contacts after a delay dependent on the time setting. These contacts are in series with another set on the directional element, so that the timing function is independent of voltage variations. Tripping can occur only for an actual reversal of power maintained for the predetermined time interval. The return of power to its normal direction at any time during this interval prevents undesirable tripping.

The GGP relay is a compact, single unit, housed in a space-saving, 5½ by 12-inch universal case to provide accurate sensitivity protection. The standard relay has a sensitivity of one-half of one per cent of full-load power.

Electrical Contacts

ELECTRICAL contacts, possessing the high conductivity of pure silver as well as the low, constant resistance, are now being marketed to manufacturers of electrical equipment under the trade name of "Gibsiloy" by the Gibson Electric Co., 548 Blvd. of the Allies, Pittsburgh, Pa.

Because of its ductility, Gibsiloy—a powdered metal composition—may be formed into a wider variety of shapes

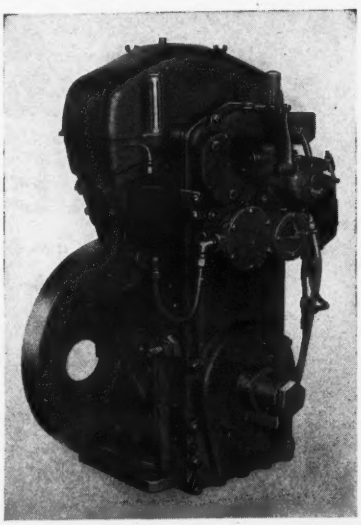


than similar materials which, owing to their brittleness, must be cast to form. Moreover, Gibsiloy may be punched, machined, drilled, tapped and otherwise worked as easily as ordinary alloys. Hardnesses range from that of pure silver to 200 Brinell B scale Shore Scleroscope for some grades of silver-nickel-tungsten. They are free from galling and their high arc resistance greatly reduces welding or sticking.

The most common forms of Gibsiloy are silver-nickel, silver-nickel-cadmium, silver-nickel-tungsten, silver-nickel-molybdenum, silver-tungsten, and silver-molybdenum. Each form is produced in different grades possessing varying physical properties. Certain forms, particularly silver-nickel-cadmium, greatly reduce transfer of metal from one contact to another on d.c. circuits.

Small V-Type Diesel Engine

EFFICIENCY and economy of the Diesel engine is made available to the small power user with the new Model 45-A engine developed by Fairbanks-Morse & Co., Chicago, Ill.



Offered as a power unit or generating set, this engine of V design is available in one and two cylinder sizes with a capacity of 5 and 10 hp. respectively, or in the generating sets, 3 and 6 kw., d.c.

Type 50 Variac

THE NEWEST addition to the line of Variacs made by General Radio Co., Cambridge, Mass. is the Type 50, available in a 115-v. model at 5 kv-a. and in a 130-v. model at 7 kv-a. These are continuously variable autotransformers intended for industrial applications and are designed to give reliable, continuous service.

Particular applications include line voltage correction, voltage control in rectifier systems, speed control on electric motors, stage lighting control, and the control of heating in electric furnaces.

Both models can be connected to give output voltages 17.5 per cent above line voltage: 0 to 135 v. for the 115-v. model and 0 to 270 v. for the 230-v. model. Ratings are for 60-cycle service, but

Variacs can be operated at 50 cycles with slightly greater heating and slightly reduced rating.

The mounting is arranged so that the Variac can be built into larger equipment or used on the laboratory bench. Two or more units can be ganged for operation on polyphase systems.

Water Analysis

As A convenient and time-saving means of making water analyses, the National Aluminate Corp., 6216 W. 66th Place, Chicago, Ill., has developed and placed on the market the Nalco Phototester. This is used to determine the constituents when colorimetric or turbidimetric reactions take place in water. It is said that the accuracy and reproducibility of results are greater than can be achieved by visual or ordinary methods and that it eliminates errors due to eye fatigue and personal judgment of color

intensity. The Phototester operates on the principle that the current which flows in the circuit containing a photoelectric cell is proportional to the illumination which the cell receives. Any chemical precipitation or change of color in the solution being tested, changes the light transmission and subsequent current generation. From plotted curves the instrument can be standardized for a wide range of analytical applications. It is designed as a portable instrument, self-contained and the power source is flashlight batteries. For non-portable use the batteries may be replaced by 6 volt bell-ringing transformer.

Prevent scale troubles - the DEARBORN WAY

Water Samples Are Carefully Analyzed in the Dearborn Laboratories

With the data obtained from these laboratory tests and with complete information regarding the water supply and operating conditions, it is possible for Dearborn to recommend an effective chemical treatment and control procedure.

Wasted fuel, frequent turbining, expensive tube replacements—all result from bad scale conditions. Thousands of steam plants all over the country have eliminated these troubles and are making substantial savings by using Dearborn Water Treatment and Engineering Service. Not only does Dearborn Treatment prevent the formation of new scale, but it gradually disintegrates scale already present, without boiler shutdowns.

But the Dearborn Water Treatment System does not stop with eliminating scale troubles. It also provides full protection against pitting and corrosion. Dearborn also takes the necessary steps to determine and correct the causes of steam contamination.

The cost of Dearborn Treatment is small compared with the savings it makes and the freedom from worry it brings both plant owner and engineer. Dearborn engineers will be pleased to make an analysis of your plant and show you what savings Dearborn Treatment will make.

Dearborn Chemical Company
Dept. F
310 S. Michigan Ave., Chicago

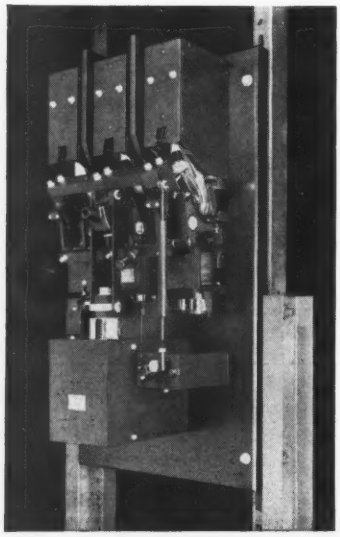
Dearborn
TRADE MARK REGISTERED

WATER TREATMENT AND ENGINEERING SERVICE

CHICAGO • NEW YORK • LOS ANGELES • TORONTO and PRINCIPAL CITIES

Compact Air Circuit Breaker

APPROXIMATELY one-half the size of previous devices of the same rating is a new air circuit breaker recently announced by the Westinghouse Electric and Manufacturing Company. Among the most important improvements in these new breakers is a "De-ion" arc chamber, a device which is simple in construction, operates on either alternating current or direct current, has long life, and under normal operating conditions requires no maintenance. It operates on any current within the range of established interrupting ratings; arcing current is limited to one-half cycle, which minimizes the noise and flash accompanying the interruption of a short circuit.



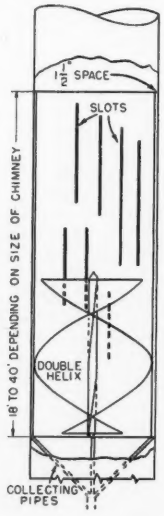
The circuit breaker itself is stronger than previous air breakers. No carbon is used in the contacts; and the protective contact supports have been strengthened. Heavy current through the flexible conductors to contact supports causes a magnetic reaction that increases contact pressure and gives increased protection to the main contacts.

Moving parts on the solenoid mechanism have been reduced to a minimum number, the moving core of the mechanism being connected directly to the breaker operating level. The new breakers are adjustable to front-of-board, drawout, back-of-board, and separate enclosure mounting. Five sizes are available, covering a range of operating currents from 15 to 6000 amp. at 600 v. on a-c service—15 to 10,000 amp. direct current—and have interrupting capacities of from 40,000 to 80,000 amp.

Fly Ash Arrestor

THE NEW Whirlex Fly Ash Collector of The Fly Ash Arrestor Corp., Birmingham, Ala., is being marketed through the company's sales organization with Milton Paul Burt, 1061 Rosemont Ave., Chicago, Ill., as director of sales.

The arrestor consists of a double helix in the lower part of a dust chamber from 18 to 40 ft. high depending on the size. The device is installed in the chimney above the level of the breeching so that there is a space of about 1½ in. between the cylindrical portion and the stack. The flue gases passing through the helix are given a whirling motion and the fly ash thrown to the outside passes through slots into the dead space between the cylinder and stack. There it falls downward by gravity through a system of collecting pipes to an ash receptacle.



An installation made earlier in the year at the Louisville Provision Co., on two 250 hp. stoker fired boilers is said to have stopped all complaints and made it possible to blow the flues every four hours instead of once a day. This has resulted in a reduction of flue gas temperature of about 100 deg. F. to average of 425 deg. F. with an appreciable increase in efficiency. When burning about 20 t. of coal a day, approximately 600 to 1000 lb. of fly ash and soot are removed from the stack each 24 hr.

Projection Unit Heater with Anemostat

NEW fields for unit heating have been opened up according to The Trane Co., La Crosse, Wis., with the announcement that the Trane Projection Unit Heater is now available with an Anemostat. Fourteen months of experimentation have resulted in the adaptation of the Anemostat, originally designed for duct applications, to the four-blade propeller fan incorporated in Projection unit heaters. The vertical air stream projected straight downward is draftless and blastless, and people may sit directly under the unit in perfect comfort even on low ceiling installations. This new heater is applicable in offices, stores, greenhouses, fine shops —in fact, everywhere where evenly distributed warmth is required and for industrial plants where low velocity air currents, which are absolutely dustless, are essential to particular manufacturing processes.

Corrosion Resistant Coatings

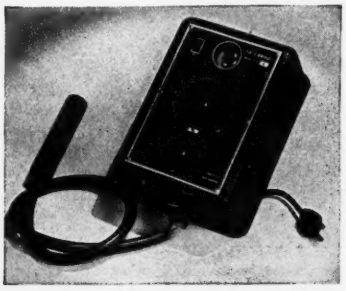
D. W. HAERING AND CO., 2308 S. Winchester Ave., in Chicago, Ill., has developed a new line of corrosion resistant coatings for external application to metal surfaces for protection from corrosion. This line of products introduces the famous organic corrosion inhibitors, developed by Haering Research, suspended in non drying bases for protection from atmospheric and subsoil conditions.

Identified under the trade name, IN-HIB-CO, these products introduce the chrom glucosate compounds for corrosion control to new fields of use. These products are prepared in several forms to meet varying temperature requirements and may be applied by brushing, spreading or spraying on exposed surfaces. The films formed are resistant to moisture and contain sufficient film inhibitory to protect underlying surfaces from corrosion for an indeterminate period of time.

Small quantities of IN-HIB-CO cover large surfaces, one pound of the average product covering one thousand square feet of surface providing positive protection from corrosion. IN-HIB-CO corrosion resistant coatings are being marketed in 50, 115, 250 and 400 pound drums.

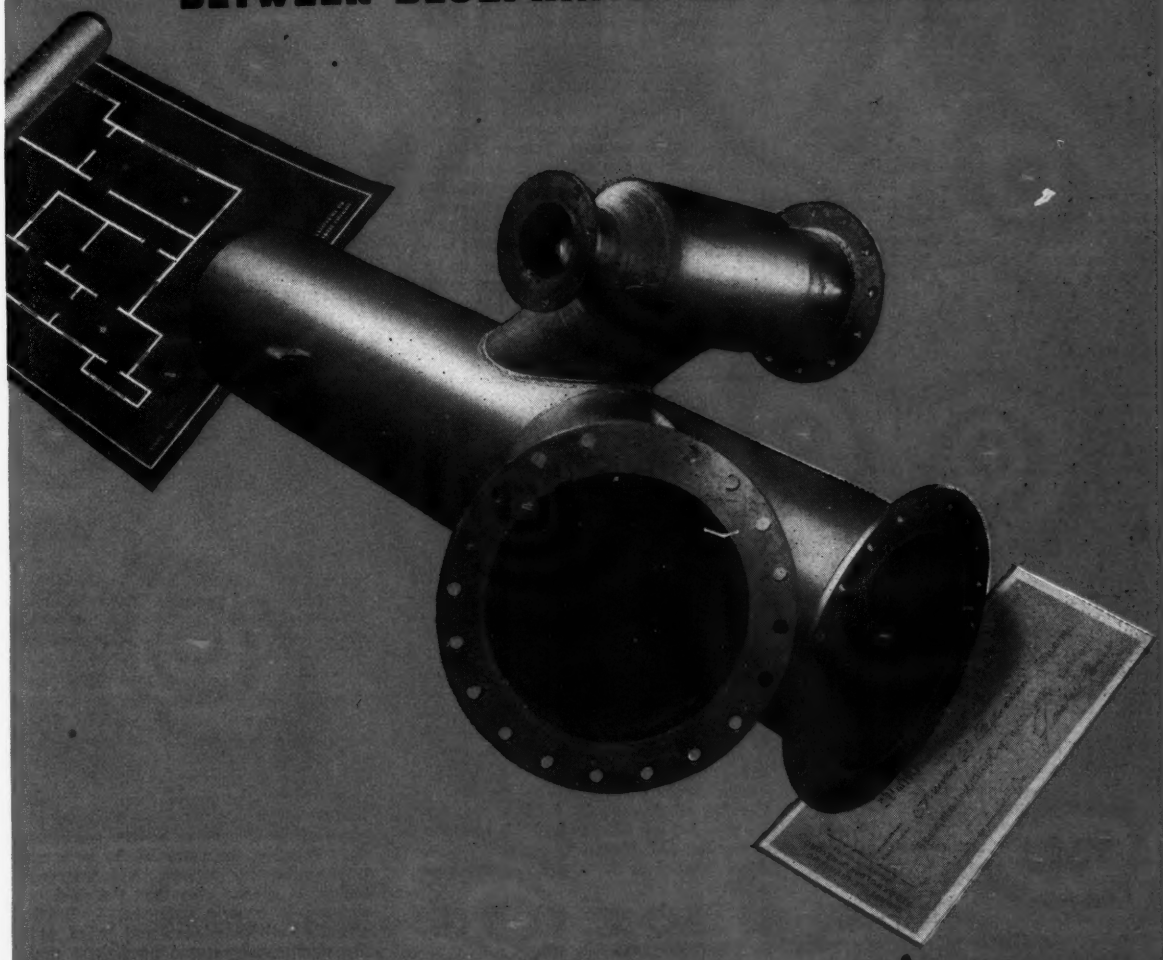
Alkali Washing Solutions Tester

INDUSTRIAL INSTRUMENTS, INC., 156 Culver Ave., Jersey City, N. J., announces the RD-1 Solu-Bridge, a simple and economical type of solutions conductivity tester. Although it was primarily designed for measurements of sodium hydroxide content similar bridges are available with suitable direct calibration for many other applications. To test a solution, the dial upon the panel is rotated until the electronic "eye" opens to the maximum value. When the green shadow in the "eye" reaches its widest angle, the balance point is reached at this point, the concentration of the solution is directly indicated on the panel scale.



Shortest Bridge

BETWEEN BLUEPRINTS AND DIVIDENDS



YOUR money begins to flow *out* when you start your new plant or modernization. But it won't flow *in* again until the job is finished and running.

Grinnell Prefabrication can cut days and weeks off the time between investment and return. Accurate sub-assemblies like that shown are simply and rapidly field-welded into a finished piping system.

Grinnell plants are strategically located to serve the continent quickly. For piping that's an exact interpretation of your plans, pre-tested to qualify for insurance, and constructed to standards commercially practical and technically sound, "Give the plans to Grinnell." Grinnell Company, Inc., Executive Offices, Providence, Rhode Island. Branch offices in principal cities.

PREFABRICATION BY **GRINNELL**

WHEREVER **PIPING** IS INVOLVED

News from the Field

CUTLER-HAMMER, INC., Milwaukee, Wis., has appointed H. E. Ankeney to take charge of the Company's Indianapolis territory with office at 307 N. Pennsylvania Ave. Mr. Ankeney, who has been associated with the C-H Chicago office, is a member of Eta Kappa Nu, honorary electrical engineering fraternity, and of the American Institute of Electrical Engineers.

LEADING authorities are scheduled to speak at the two-day meeting of the Eastern Air Conditioning Conference at Lehigh University, Bethlehem, Pa., November 10-11, 1939. Papers to be presented are as follows: Refrigeration Storage for Handling Peak Loads, by Carl F. Boester; Hotel Guestroom Air Conditioning Practices, by John R. Hertzler; Analysis of Air Conditioning for an Educational Building, by S. R. Lewis; Air as a Vehicle of Contagion, by Dr. W. F. Wells; A Realistic Approach to Hospital Air Conditioning, by C. F. Neargard; Uses of Air Conditioning in Hospitals, by Dr. M. B. Ferderber; Air in War, by Dr. Philip Drinker; Creating a Demand for Air Conditioning, by J. C. Rosenmiller; Moisture Removal from Blast Furnace Air, by L. L. Lewis; Climate and Air Conditioning, by J. C. Albright; The Effect of Modified Atmospheres on Cold Storage, by Charles Brooks.

HEATING and Ventilating and Air Conditioning are still among the most popular home-study courses of the University Extension Division, Rutgers University, New Brunswick, N. J. Frequent revision of both text books and assignment material keeps courses in step with the constant changes in these fields. Revised and enlarged in June, the Heating and Ventilating course is already in considerable demand.

HARLOW B. MONDAY, prominently indentified with coal sales work since 1921, has joined the Marketing Division staff of Appalachian Coals, Inc. His headquarters will be in the General Office of the agency in Cincinnati, O. He will be engaged in sales promotion work for the Appalachian agency, working with J. K. Taggart.

CARL R. BROWN, production engineer of the Sioux City Gas & Electric Co. since 1932 and an employee of the company since 1922, died in Sioux City, Ia., on September 6th. He was born in St. Albans, Vermont, in 1899, graduated from high school there and from the U. S. Naval Academy in June, 1922.

GANO DUNN, president of the J. G. White Engineering Corp. and of Cooper Union, has been chosen as the 1939 recipient of the Hoover Medal, "awarded by engineers to a fellow engineer for distinguished public service", it is announced by John V. W. Reynders of New York, chairman of a board of award representing the four national societies of civil, mining and metallurgical, mechanical, and electrical engineers. "The medal," according to the announcement of the board, "signalizes great unselfish, non-technical service by engineers to their fellowmen." It will be formally presented to Mr. Dunn under the auspices of the American Institute of Electrical Engineers during the Institute's annual convention in New York City, January 22 to 26, 1940.

PUBLIC SERVICE ELECTRIC & GAS CO., Newark, N. J., has placed orders covering a 50,000 kw. superposed turbine-generator and two high pressure boilers for the Marion Generating Station in Jersey City. Work at the station in preparation for the installation will begin immediately and will cost, including the necessary extensions to the turbine and boiler rooms, approximately $7,500,000. When completed Marion will be one of the most efficient generating stations in the Public Service system.

At Essex Generating Station a 50,000 kw. machine was put in service in 1938 and a 100,000 kw. unit, to be in service in 1940, is under construction at Burlington Generating Station.

FOR THE past three years the Industrial Unit Heater Association has been systematizing and publishing its established standards and working data. At its Chicago meeting on October 6, 1939, further extension of this work was approved. It is intended that the Engineering Committee shall develop recognized practices for the application of Unit Heaters supplied with hot water. Further study is also to be undertaken on corrosion in steam heating systems in cooperation with other interested groups.

FIVE day courses on Arc Welding Design and Practice will be given by John Huntington Polytechnic Institute in collaboration with Lincoln Electric Co. at 3133 Euclid Ave., Cleveland, Ohio on Dec. 8, 1939, Jan. 8, Feb. 12, Mar. 28, Apr. 22 and May 27, 1940. Courses, under the direction of E. W. P. Smith, consulting welding engineer, will cover, generators, use of a.c. and d.c. current, stress distribution in welded joints, use of the shielded arc.

STATEMENT OF THE OWNERSHIP, MANAGEMENT, CIRCULATION, ETC., required by the Acts of Congress of August 24, 1912, and March 3, 1933, of POWER PLANT ENGINEERING, published monthly at Chicago, Illinois, for October 1, 1939.

State of Illinois, } ss.
County of Cook, }

Before me, a Notary Public, in and for the State and county aforesaid, personally appeared K. L. Rice, who, having been duly sworn according to law, deposes and says that he is the Business Manager of the Power Plant Engineering and that the following is, to the best of his knowledge and belief, a true statement of the ownership, management (and if a daily paper, the circulation), etc., of the aforesaid publication for the date shown in the above caption, required by the Act of August 24, 1912, as amended by the Act of March 3, 1933, embodied in section 537, Postal Laws and Regulations, printed on the reverse of this form, to wit:

1. That the names and addresses of the publisher, editor, managing editor, and business managers are:

Publisher, Technical Publishing Co., Chicago, Ill.
Editor, R. E. Turner, Chicago, Ill.
Managing Editor, None.
Business Manager, K. L. Rice, Chicago, Ill.

2. That the owner is: (If owned by a corporation, its name and address must be stated and also immediately thereunder the names and addresses of stockholders owning or holding one per cent or more of total amount of stock. If not owned by a corporation, the names and addresses of the individual owners must be given. If owned by a firm, company, or other unincorporated concern, its name and address, as well as those of each individual member, must be given.)

Technical Publishing Co., Chicago, Ill.
Arthur L. Rice, Chicago, Ill.
Charles S. Clarke, Chicago, Ill.
Kingsley L. Rice, Chicago, Ill.
Ralph E. Turner, Chicago, Ill.
Andrew W. Kramer, Chicago, Ill.
John O. Aarvold, Chicago, Ill.
Otto Kaad, Chicago, Ill.
Walter Painter, Chicago, Ill.
Richard H. Morris, Chicago, Ill.
Edwin C. Prouty, Chicago, Ill.
Madge W. Rice, Wilmette, Ill.

3. That the known bondholders, mortgagees, and other security holders owning or holding 1 per cent or more of total amount of bonds, mortgages, or other securities are: (If there are none, so state.)

There are none..

4. That the two paragraphs next above, giving the names of the owners, stockholders, and security holders, if any, contain not only the list of stockholders and security holders as they appear upon the books of the company but also, in cases where the stockholder or security holder appears upon the books of the company as trustee or in any other fiduciary relation, the name of the person or corporation for whom such trustee is acting, is given; also that the said two paragraphs contain statements embracing affiant's full knowledge and belief as to the circumstances and conditions under which stockholders and security holders who do not appear upon the books of the company as trustees, hold stock and securities in a capacity other than that of a bona fide owner; and this affiant has no reason to believe that any other person, association, or corporation has any interest direct or indirect in the said stock, bonds, or other securities than as so stated by him.

5. That the average number of copies of each issue of this publication sold or distributed, through the mails or otherwise, to paid subscribers during the twelve months preceding the date shown above is .....
(This information is required from daily publications only.)

K. L. RICE,
Business Manager.

Sworn to and subscribed before me this 29th day of September, 1939.

JOHN O. AARVOLD.
(My commission expires March 20, 1940.)

Pressure piping pre-fabricated by a qualified pipe fabricator is delivered to the job in a series of sub-assemblies that are commercially practical, heat-treated or stress-relieved when necessary, shop tested, accurately aligned, thoroughly cleaned and inspected . . . all essential to rapid and economical erection.

Specialized piping experience enables the qualified fabricator to contribute suggestions that frequently simplify layout and reduce costs.

The many facilities (work rotating fixtures, straightening tables, pre-heating equipment, etc.) available only in the qualified pipe fabricating plant, and the use of pressure welders whose work is subjected to rigid inspection and periodic physical test, assures welding that is of superior quality and can be insured.

Use pre-fabricated piping on your next pressure piping job. Its many important advantages cannot be disregarded by the smart purchaser.

THE PIPE FABRICATION INSTITUTE

PFI — *Devoted to the Technical and Economic Problems in Piping*

1108 CLARK BUILDING PITTSBURGH, PA.

Parker Dam Turbines Purchased

TURBINES AND GOVERNORS for initial installation of Units 1, 2 and 3 in the Parker Dam power plant were ordered Oct. 12 by Secretary of the Interior Harold L. Ickes. Three 40,000-hp. turbines will be furnished by the S. Morgan Smith Co. on a bid of $749,000, the three governors with pumping equipment by the Woodward Governor Co. on a bid of $56,040.

Three main generating units will comprise the initial installation of power equipment. Generators will be ordered under another contract and a contract for excavation for the power house and appurtenant works will be awarded in the near future. Ultimately a fourth unit will be installed. The 5000 sec. ft. of water under a head of 72 ft. will be supplied by a 22 ft. diam. penstock.

Parker Dam, 155 mi. downstream from Boulder Dam on the Colorado River, was built by the Bureau of Reclamation for the Metropolitan Water District of Southern California to divert water into the Colorado River Aqueduct. Although constructed primarily for the purpose of supplying Los Angeles and other cities in Southern California with water, Parker Dam also will serve to generate electric energy for the District and for irrigation pumping requirements. Half of the power to be generated at Parker Dam belongs to the Government, which also has the right to use or dispose of the other half until such time as it is needed by the Metropolitan Water District of Southern California.

Repairs on Valmont Plant

By C. P. O'Brien

TEMPORARY changes in the plant and work on the coal pulverizing building of the Public Service company's Valmont plant east of Boulder, Colo., are under way. The plant was seriously damaged last July 26, in a blast caused by the explosion of powder-fine coal dust, which is pulverized in the building.

John D. Elftman, plant superintendent, said before any permanent changes in the plant are made, a nationwide search is being made for a safer system than formerly used in pulverizing the coal and preventing explosions. The system formerly used is one in which there is only a minute chance of explosion, but was not absolutely safe, as the blast proved.

The plant has not been out of operation pending repairs.

A change in personnel was brought about. C. A. Johnson, formerly a relief engineer at the plant, has been named successor to G. Elmer Shonts, one of the blast victims, and Jack Foos, former relief mill man, succeeds the other victim, Benjamin J. Groothius. Foos now becomes mill operator. William Lewis has been appointed relief engiman.

H. W. Button Elected Vice President

H. W. BUTTON, for a number of years Chief Engineer of the Laclede Power & Light Co. of St. Louis, Mo., was elected vice president in charge of operations at a meeting of the Board of Directors of that company. Mr. Button has devoted more than twenty-six years to the light and power industry including periods of service with manufacturing companies and operating companies in engineering and operating capacities. He has been connected with the Lacede Power & Light Company and affiliated companies for the past thirteen years. He is a graduate of Worcester Polytechnic Institute, Class of 1912.

Work Begins On $50,000,000 Denison Dam and Reservoir Project

FOLLOWING investigations and surveys for a number of months past, initial work is being placed under way on the Denison dam, reservoir and hydro-electric power project in the vicinity of Denison (Grayson County), Tex., under the direction of the United States Engineer Office, Southwestern Division, Little Rock, Ark. Known officially as the Denison Dam and Reservoir Project, the development was authorized by Congress under the Flood Control Act in June 1938, and is estimated to represent a gross investment of about $50,000,000. The dam site is located on the Red River, approximately five miles north of Denison and about 15 miles southwest of Durant, Okla. The dam will be of rolled earth embankment type, 14,000 ft. in length, with maximum height of 165 ft.; it will have a maximum base width of close to 1150 ft., and a crest width of 40 ft. The construction of the dam will create a reservoir with total estimated capacity of 5,285,000 acre-ft.; this reservoir, filled to the elevation of the spillway crest, will extend upstream about 80 miles, following the main branch of the Red River, to the vicinity of Gainesville, Tex.; there will be a northern branch of the reservoir extending about 60 miles, to a point near Ravia, Okla.

The hydroelectric power development is scheduled to proceed this fall, when awards will be made for power house substructure and other features of the work. It will have an initial capacity of 66,000 kw., divided into two 33,000-kw. hydraulic turbine units. Provision will be made for the later installation of two additional generators of the same rating. The turbines will operate under a head of about 104 ft. The dam will provide an estimated average annual stream flow of 4,300,000 acre-ft., substantially all of which will be available for power generation. Project will include transmission lines, power substations and switching stations, and distribution systems to reach all surrounding districts, providing electric power for different industrial and commercial service. The project will be carried out under the supervision of the District Engineer, United States Engineer Office, Denison, Tex., with bids to be received and contracts awarded from that point.

Ignitron Rectifiers Purchased

THE FIRST IGNITRON rectifier to be used in a steel mill, will be a 100-kw., 250-v. Westinghouse unit purchased by the Carnegie-Illinois Steel Corporation at Braddock, Pa. This unit will tie into plant bus and furnish power for miscellaneous direct-current equipment.

The ignitron rectifier and associated apparatus will be designed to operate from a three-phase, 6600-v. power-supply system. The ignitron unit will consist of two assemblies of six ignitron tubes, each being complete with equipment for maintaining and indicating vacuum. The unit will be rated 1000 kw. at 250-v. direct-current continuously with overload capacity of 125 per cent for two hours and 200 per cent for one minute. The rectifier unit will be completely automatic. The high efficiency, ease of installation, and compactness of the ignitron rectifier makes it a very desirable source of direct-current power in a steel plant. It is expected that this rectifier will be installed before January, 1940.

A 3000-kw. 600-volt ignitron rectifier was also purchased by the Wisconsin Electric Power Co. This unit will be installed at the Commerce Street Power Plant in Milwaukee and will feed into the 600-volt station direct-current bus and deliver power for street-railway service.

This unit also will consist of two assemblies of six ignitron tubes. It will receive power from a 3-phase, 60-cycle, 13,800-v. system-through an oil-insulated, watercooled transformer. The unit will be rated 3000 kw. at 600 v. direct current continuously with overload capacity of 150 per cent for two hours and 300 per cent for one minute. The control for the unit is semi-automatic.

Aside from the high overall efficiency of the ignitron rectifier, its compactness also made it preferable in the limited substation space available. It is expected that the unit will be installed by the end of 1939.

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Platte River Water and Hydro-Electric Power Development in Nebraska

THE AK-SAR-BEN Public Power and Irrigation District, South Bend (Cass County), Neb., has made application to the State Engineer for approval of its organization, to carry out a power and irrigation project on the Platte River. It is proposed to construct a 25-ft. on-stream dam in the vicinity of South Bend, creating an artificial lake about 5 miles long. A hydroelectric power plant will be built near the dam, with transmission lines to extend to different parts of Cass and Sarpy Counties, with power substations, switching stations and service facilities. It is estimated that the project will provide for the irrigation of about 7800 acres of land in the two counties noted, in addition to the power development, with further benefits of soil conservation and flood control, and the establishment of a recreational area around the artificial lake, where a group of approximately 1000 cabins will be located. Cost is estimated at $4,500,000 and it is proposed to begin work as soon as approval has been secured.

More Capacity for Commerce Street

THE WISCONSIN ELECTRLC POWER CO. has placed an order with the Allis-Chalmers Mfg. Co. for a 35,000 kw. automatic extraction, 3600 r.p.m. hydrogen cooled condensing turbo-generator for installation at its Commerce Street Plant in Milwaukee. Delivery is scheduled to be made in time to have the plant addition ready for operation before the fall of 1942.

Steam conditions for the new turbine normally will be 1200 lb. per sq. in. ga. and 900 deg. F. Probably 65 per cent of the steam will be taken out of the turbine with automatic extraction at 35 lb. per sq. in. ga. the remainder being taken out at 160 lb. per sq. in. ga. Steam to the turbine exhaust will be condensed at 28½ in. It is planned to use the unit as spinning reserve during the lighter load periods and to call upon the condensing capacity only when the efficiency of this section is better than that of the other stations on the system.

The addition is required to provide for future growth of the electric and steam heating loads and for the release of certain old boilers from continuous duty. Plans also include the installation of a high-pressure boiler and auxiliary equipment in a new building. The cost of the entire project is estimated at $4,137,000.

Two New 35,000-kw. Units

ANNOUNCEMENT was made recently of the purchase of two nearly identical Westinghouse 35,000-kw. hydrogen-cooled turbine generators. One unit will be installed in the E. Peoria, Plant of the Central Illinois Light Co., and the other in the Toronto, plant of the Ohio Edison Co., both subsidiaries of the Commonwealth & Southern Corp. They are rated at 43,750 kv-a, 3600 r.p.m. 80 per cent power-factor, 3 ph., 60-cycle and have direct-connected main and pilot exciters. The Peoria machine will generate at 14,400 v. and the Toronto machine at 11,500 v. Both generators will be driven by tandem-type steam turbines of conventional design with inlet steam conditions of 800 lb., 850 deg. F. T.T. It is expected that both machines will be installed by mid-summer of 1940.

Water Cooling Tower Association

MANUFACTURERS of cooling tower equipment have recently organized the Water Cooling Tower Association, with offices at 7 E. 44th St., New York City. At a recent meeting, L. T. Mart of The Marley Co., was elected President, W. J. Hoffman of Lilie-Hoffmann Cooling Towers, Inc., Vice-President, and W. J. Parker, 7 E. 44th St., New York City, Secretary-Treasurer.

Membership in the association includes Binks Manufacturing Co., Foster Wheeler Corp., The Fluor Corp., Ltd., Lilie-Hoffmann Cooling Towers, Inc., The Marley Co., and Research Corp.

It is reported that the association has a complete program on future accomplishments, one of which is a standardization program and the establishment of a Code of Ethics.

For the Engineer's Library

Recent bulletins and catalogs on power plant equipment listed for your convenience in securing specific information. Power Plant Engineering will be glad to procure for you any free literature that you desire.

Heat Exchangers

After Coolers—A new bulletin illustrates and describes this subject, giving design, construction, operation, sizes and capacities. Pennsylvania Pump & Compressor Co.

Heat Exchanger—Bulletin 1612 describes the design and applications of an exclusive type of heat exchanger for heating or cooling fluids of low heat conductivity or high viscosity. Designs for various types of service are described, and more than 60 present applications in the oil and gas industry, chemical process work and general industrial plants are listed. The Griscom-Russell Co.

Meters and Instruments

Thermometers and Pressure Gages—This booklet, No. 2-17, describes all three — vapor-actuated, gas-actuated and mercury-actuated—types of Brown thermometers. Indicating and one, two and three pen recording models are illustrated. The modern, rectangular case, styled by Henry Dreyfuss, gives added beauty and distinction to these new instruments. The Brown Instrument Co.

Optical Pyrometer—A well-illustrated catalog N-33D describing the new Optical Pyrometer shows how this instrument is used in the production of metals, ceramics, glass, etc., as well as in the laboratory. A series of close-up photographs show at a glance how the instrument is operated. Also included is a discussion of the fundamentals of Optical Pyrometry so written as to be easily understood by the non-technical reader. Leeds & Northrup Co.

Gyrometer, a device for integrating the flow of any fluid, whether liquid or gaseous, is illustrated and described in a new Bulletin, No. 120, giving specifications and applications. Simplex Valve and Meter Co.

Electrical Equipment

Motors for Power Station Auxiliaries — Induction-motor drives for power-station auxiliaries are illustrated and described in a booklet B-2218. A helpful arrangement is adhered to in that a NEMA definition is given for each class of machine, such as open; drip-proof; splash-proof; self-ventilating, enclosed; and totally enclosed, fan cooled. These definitions are followed by illustrations and descriptions of typical units under the particular class. Included also are discussions of structural features, bearings, stator windings and insulation, and form-wound coils for open-slot machines. Westinghouse Electric & Mfg. Co.

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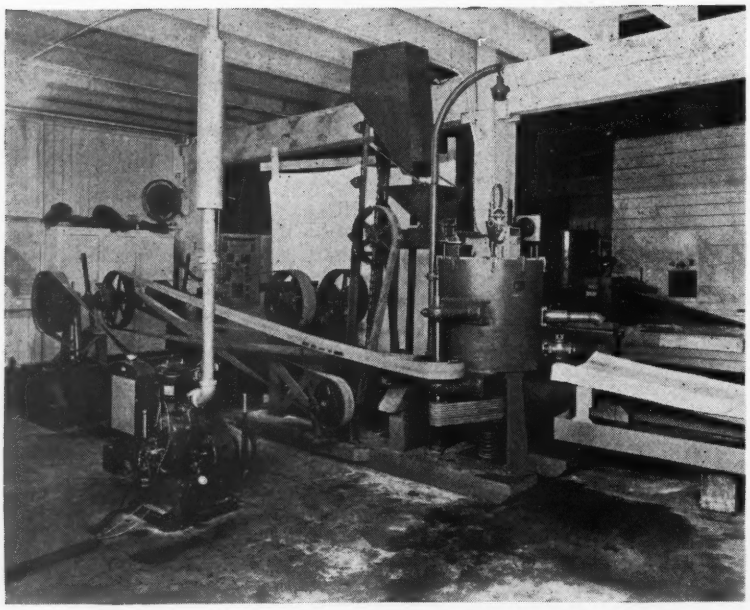

Diesel by Air

THIS 15 hp. G.M. Diesel now driving a 10 t. gold mill in the rich goldfields of the Yellowknife region on the north arm of Great Slave Lake had an eventful trip. On the trip from Detroit to the plant, just 250 mi. south of the Arctic circle, it traveled by rail, truck, aeroplane and raft. The air freight from Edmonton to Yellowknife is $720 a ton and it is estimated that the saving in weight of the two cycle engine saved some $360 in air freight alone. Fuel is flown in at the same rate, 36 ct. a pound for air freight alone!

Group - Operated Disconnecting Switches—A new leaflet, descriptive data 36-160, describes outdoor group-operated disconnecting switches. Supplied in 7.5 to 161-kv. sizes, the units have a vertical-break arrangement on each pole using three insulator stacks, one rotating to open and close the switch blade. Westinghouse Electric & Mfg. Co.

Motors—A new 28 page booklet B-6029 contains a vast amount of buyers' data on Lo-Maintenance Motors and Texrope Drives. The booklet is designed to present a wide range of facts that, in every industry, will help specifiers and buyers in estimating costs, types, and sizes of drive equipment and motors to be used under various operating conditions. It is in ready reference form and will be of special value to industrial engineers, architects, builders and contractors. Allis-Chalmers Mfg. Co.

Boilers

Oilbilt Boilers—This 8-page catalog clearly describes and illustrates Oilbilt Boilers which have won country-wide acceptance on the basis of economical performance. The Cleaver-Brooks Co.

Water Cooled Furnaces—A new 32-page bulletin discusses the functions of water cooling for boiler furnaces, describes and shows by appropriate illustrations interesting details of B&W water-cooled furnace constructions and varied typical applications. The Babcock & Wilcox Co.

Piping Accessories

Tile Conduit for underground steam or hot water lines under the trade name of ADSCO-Bannon Tile Conduit is described in detail in a new 12 page illustrated Bulletin No. 35-67B. Also included in the bulletin is data on ADSCO Cast-Iron Conduits for reinforcing steam lines under roadways and on ADSCO-Fiberglas Insulation for the thermal insulation of underground lines. American District Steam Co.

Steam Specialties—A Check Chart gives a very efficient system for checking traps through the entire plant and includes a description of the traps for each particular application. Hoffman Specialty Co., Inc.

Insulation—Many different types of insulating materials are illustrated and described in a new bulletin giving applications, sizes, prices. Baldwin-Hill Co.

Gasket Marker. Crane Packing Co., 1800 Cuyler Ave., Chicago, Ill., has available for free distribution to engineers a new gasket marker. Over 10 in. long and about 3 in. wide, this marker made of heavy celluloid can be used for marking either ring type or full face gaskets, for pipe sizes ranging from ¾ to 10 in. The new marker eliminates the use of dividers and the necessity of reference tables.

Water Treatment

Water Treatment—A new 16-page pocket size booklet entitled Solving the Boiler Scale Problem with Sand-Banum gives a complete discussion of this product and its use in the treatment of boiler water. American Sand-Banum Co., Inc.

Electro Chemical Feed—An accurate and reliable feed made for apportioning chemicals in wet form at a constant or variable rate is fully illustrated in 8-page Bulletin 2233 giving specifications. The Permutit Co.

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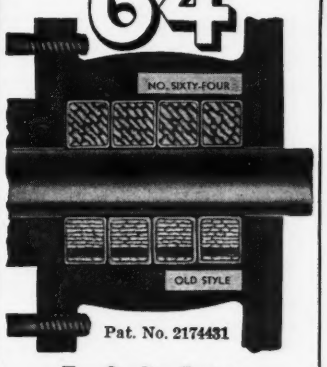

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Miscellaneous

Vacuum Cleaner—A new large size portable vacuum cleaner with a dirt capacity of 7½ cu. ft. is illustrated and described in a new 2-page bulletin. The Spencer Turbine Co.

Bearings—A slide rule listing over 800 sizes of standard stock bronze bearings has been made available by the Johnson Bronze Co.

V-Belt Fasteners—Bulletin No. V-200 covers a new line of Alligator V-Belt Fasteners for "B", "C" and "D" section V-Belts. The bulletin shows how the fasteners are applied and illustrates various types of applications where endless V-Belts could not be used without costly dismantling of the drives. Flexible Steel Lacing Co.

Welding—A new 16-page bulletin, "101 Welding Ideas for Low-Cost Maintenance," illustrates and describes a wide variety of money-saving repair, fabrication and structural applications of arc welding. The Lincoln Electric Co.

Pumps—Bulletin 260-B11D illustrates and describes turbine pumps which are offered in bronze fitted, all iron and all bronze. Design features and installation views are included in the bulletin. Selection tables and price list are carried in a supplemental publication bearing form number E11G/L11A4. Roots-Connersville Blower Corp.

New Engineering Books

MacQuown's Proximate Coal Analysis. District No. 2. Published by the National Coal Publications, 210 Grant St., Pittsburgh, Pa. Size 5 by 7 in., 80 pp. loose leaf, flexible fabricoid binding. Price, $10.00.

A comprehensive compilation of coal analysis of practically every size produced by every shipping mine within District No. 2, cross-indices and alphabetical lists of mines and companies and notations reflecting changes in the names and operators and mines since the data was submitted to the National Bituminous Coal Commission by the District Producers Board. District No. 2 now available covers western Pennsylvania. Books for other districts will be ready soon. Districts 1, 2, 3, 7, 8, 9 and 10 are or will be $10.00 per copy, districts 4, 5, 6, 11, 12, 13, 14 and 15, $5.00.

Handbook of Chemistry and Physics. 23rd Edition. 2239 pages, 7⅛x4¾ inches. De Luxe edition bound in flexible Fabrikoid Gilt edged. Chemical Rubber Publishing Co., 1900 W. 112th St., Cleveland, Ohio. 1939. Price, De Luxe edition, $6.00; regular edition, $3.50. 50 cents additional in foreign countries.

Larger and more comprehensive than ever, this 23rd edition of this valuable handbook contains an amazing amount of concentrated information. Ever since the first edition of this book was published in 1913 it has grown steadily larger. It is exceptional in that it provides in one volume comprehensive data on the three fundamental services—Chemistry, Physics and Mathematics. It should be as useful to the engineer as it is to the chemist. In this new edition the material is arranged in five general divisions as follows: 1, Mathematical Tables. 2, Properties and Physical Constants. 3, General Chemical Tables and Specific Gravity and Properties of Matter. 4, Heat and Hygrometry, Sound, Electricity and Magnetism and Light. 5, Quantities and Units, Conversion Tables and Miscellaneous Tables. In addition to a general revision of many tables much new material is included in this edition, in fact, it has over 400 pages of new material. It is impossible to present even a brief description of this remarkable book. It represents one of the most outstanding collections of chemical, physical and electrical data available in compact form and will be found useful to every engineer and technical worker as well as to chemists, physcists and teachers.

Air Conditioning—Eleven papers presented at the Second Conference on Air Conditioning held at the University of Illinois, Urbana, Ill., March, 1939, have been reprinted by the Engineering Experiment Station of the University as Circular No. 37. The price of the 151 pp. book is 50 cents.

Heating and Air Conditioning. Fifth Edition. By John R. Allen and James H. Walker. Published by McGraw-Hill Book Co., 330 W. 42d St., New York City. Size 6 by 9 in., cloth bound, 555 pp. Price, $4.50.

This book is too well known to need detailed review of the table of content. For over 20 yr. and through four editions the treatment has been revised and kept up to date to meet the needs of the engineering schools, the student studying by himself, and the practical engineer. Since the death of Mr. Allen, the revisions have been handled by Mr. Walker with the assistance of his associates in The Detroit Edison Co.

The book is a complete treatment of the fundamentals of air conditioning and its application to domestic and industrial service. Revisions have been made in the chapters to keep abreast of progress in equipment and practice. This is particularly true of such subjects as controls, air distribution, cooling coil performance, and load calculation. One of the most important changes has been the addition of a 31 pp. chapter devoted to a complete step by step calculation and design of an air conditioning system. The detailed treatment in this chapter illustrates the application of the principles covered earlier and is a practical amplification of the problems at the end of the individual chapters.

Vapor Charts. By Frank O. Ellenwood and Charles O. Mackey. Published by John Wiley & Sons Inc., New York, N. Y. Size 8 by 11 in., 43 pp., cloth bound. Price $2.50.

Ellenwood's Steam Charts first published in 1914 are well known to a generation of engineers and this new volume is not only a replacement of the original, far more extensive for steam, but has in addition, charts showing the thermodynamic properties of water, ammonia, freon and mixtures of water vapor and air. Six tables are also included for barometric corrections, jet velocities and squares of numbers. The vapor charts, used principally for turbine calculations, are plotted with enthalpy against specific volume on a logarithmic scale. The charts, divided into 21 sections, cover an enthalpy range of from 790 to 1650 B.t.u. per lb. and a volume range of from 0.05 to 3500 cu. ft. per lb. The water charts are in 5 sections and cover the enthalpy scale from zero to the critical condition and from saturated liquid to 6000 lb. pressure. Both authors are professors of Heat Power Engineering at Cornell University.

Physics. (Printed in German.) By Dr. Paul Wessel. Published by Ernst Reinhardt, München, Germany. Size 5 by 8 in., 514 pp. Price RM 4.90 (about $2.00).

This is an excellent text covering the entire field of physics and intended for technical schools and colleges. The treatment is clear and concise, and the fundamentals are covered with a full appreciation of recent progress in the field of higher physics. The book is divided into three parts, the first two covering mechanics of solids, fluids and gases, heat optics, acoustics and the various fields of electricity. Modern physics including the relativity, wave and quantum theories are briefly but adequately covered. The classical treatment of physics as something separate and distinct in itself, separated from the everyday world, has been avoided and the subject made alive and vital as the foundation of applied science in the everyday engineering, medical and chemical world. The third part of the book is a brief summary of important facts, formulas, 1447 test questions and answers, and important physical and mathematical tables. Dr. Wessel is now lecturer in the Wigan Technical College in Lancaster, England.

Lubricants and Lubrication. By James I. Clower. Published by the McGraw-Hill Book Co., 330 W. 42nd St., New York City. Size 6 by 9 in., 448 pp., cloth bound. Price, $5.00.

This is essentially a practical book for users and sellers of lubricants and for those who use and design machinery, with sufficient material on the source, production, refining and theory of lubrication to enable the engineer to select, apply, use and care for lubricants properly. Eleven chapters are devoted to the fundamentals of lubrication, six to the lubrication details of specific equipment such as turbines, engines and compressors, and the last chapter deals with storage and handling. The author is associate professor of machine design at Virginia Polytechnic Institute and was formerly technical editor of the Vacuum Oil Co.

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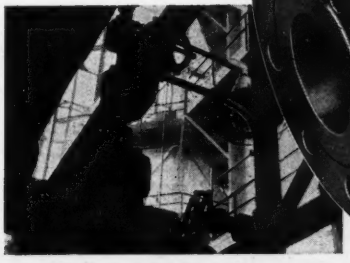

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Power Plant Construction News

Calif., Downey—Vultee Aircraft Co., Downey, plans installation of electric power equipment in one-story addition to plant, totaling about 25,000 sq. ft. of floor space. Entire project will cost about $75,000. Gordon B. Kaufmann, 627 Carondelet Street, Los Angeles, Calif., is architect.

Calif., Hawthorne—Northrop Aircraft, Inc., Hawthorne, plans installation of electric power equipment in new one-story addition to local plant, on site near Crenshaw Boulevard and 126th Street, totaling about 100,000 sq. ft. of floor space. Entire project will cost over $200,000. Work will begin at early date. B. G. Reed is company engineer.

Calif., Long Beach—Public Utilities Committee of City Council and J. W. Charleville, city manager, are considering estimates of cost, totaling $10,600,000, for a proposed municipal electric power plant. A bond issue in that amount will be arranged. Early decision will be made on project.

Conn., West Haven—Armstrong Rubber Co., Elm Street, plans installation of electric power equipment in new four-story addition, 100x150 ft., to automobile tire and tube plant. Entire project will cost about $200,000. Fletcher-Thompson, Inc., 1336 Fairfield Avenue, Bridgeport, Conn., is architect and engineer.

Ga., Macon—Georgia Power Co., Atlanta, Ga., has approved plans for new steam-electric generating plant on 22-acre tract of land on Ocmulgee River at Macon, with initial capacity of 35,000-kw., and facilities for installation of two additional units of same rating at later date, making total of 105,000-kw. for ultimate station. Cost estimated close to $4,000,000. New plant will be completed early in 1941. Company also will make extensions in transmission lines in Macon area.

Idaho, Sandpoint—Northern Idaho Rural Electrification Rehabilitation Association, Sandpoint, has plans under way for new hydroelectric generating station at outlet of Priest Lake, where site has been selected. Work on power dam is scheduled to begin soon. Cost about $150,000. Financing has been arranged through Federal aid.

Ill., Decatur—Rath Packing Co., Sycamore Street, Waterloo, Iowa, meat packer, has approved plans for one-story cold storage and refrigerating plant at Decatur, estimated to cost close to $80,000, with equipment.

Ill., Dixon—Reynolds Wire Co., South Crawford Street, plans installation of power equipment in new one-story addition to plant, on which work will proceed at once. Cost close to $170,000.

Ill., Franklin Park—Franklin Park Frozen Foods, Inc., care of J. R. W. Anderson, 1110 Harrison Street, Oak Park, Ill., engineer, plans boiler house at new plant at Belmont and Washington Streets, Franklin Park; also will install refrigerating machinery and power equipment for plant service. Entire project will cost over $125,000.

Ind., Decatur—Board of Public Works, Forest Elzey, chairman, is considering extensions and improvements in municipal electric power plant, with installation of new 5000-kw. turbine-generator unit, boiler and auxiliary equipment. Surveys and estimates of cost have been made by Froehlich & Emery Engineering Co., Second National Bank Building, Toledo, Ohio, consulting engineer.

Iowa, Brooklyn—City Council has plans under way for new municipal electric power plant, for which a bond issue of $135,000 recently was voted. Proposed to use Diesel engine-generator units and accessories. Bids will be asked in near future.

Iowa, Cedar Rapids—Iowa Electric Light & Power Co., has approved plans for expansion and improvements in local steam-electric generating station, including installation of equipment for increased capacity. Proposed to begin work early in 1940. Cost estimated close to $900,000.

Iowa, Clinton—E. I. du Pont de Nemours & Co., Inc., Cellophane Division, duPont Building, Wilmington, Del., plans installation of power equipment in new branch mill at Clinton, where large tract of land was acquired a number of months ago. It will comprise several large production units, power house, pumping station and other mechanical divisions. Cost reported close to $5,000,000. Work is scheduled to begin soon.

Kan., Kansas City—Meyer Kornblum Packing Co., 300 Central Avenue, meat packer, plans installation of power equipment in new two-story addition, 50x120 ft. Entire project will cost close to $70,000. Carl Schloemann, 6329 Bonita Avenue, Clayton, Mo., is architect.

La., Baton Rouge—Standard Oil Co. of Louisiana, Inc., plans installation of power equipment in connection with expansion and improvements in local oil refining plant, to include additional power units, pumping machinery, steel tanks for storage and distribution, and other facilities. Cost reported close to $3,000,000.

Mich., Bessemer—City Council will begin work soon on erection of power plant building for new municipal station, 42x62 ft., estimated to cost about $187,500, with equipment. Financing has been arranged through Federal aid. Ayres, Lewis, Norris & May, Wolverine Building, Ann Arbor, Mich., are consulting engineers.

N. J., New Brunswick—Johnson & Johnson, George Street, manufacturers of drugs and pharmaceutical products, surgical materials, etc., plan installation of electric power equipment in new plant on tract of land recently acquired on Route 25, North Brunswick Township. Entire project will cost over $650,000. Russell G. Cory, 30 Church Street, New York, N. Y., is engineer.

Ohio, Cincinnati—Kroger Grocery & Baking Co., 35 East Seventh Street, plans installation of power equipment in new five-story and basement plant on local site on State Avenue. Entire project will cost close to $500,000. Tietig & Lee, 34 West Sixth Street, are architects; A. M. Kinney, Inc., Carew Tower Building, is mechanical engineer.

Ohio, Marietta—Ohio Farm Bureau Cooperative Association, 246 North High Street, Columbus, Ohio, plans installation of power equipment in new commercial fertilizer-manufacturing plant at Marietta. A boiler house will be built. Entire project will cost close to $100,000. Plans also are under way for four similar plants on other sites in State, now being selected, each to cost about like amount. W. W. Carlton, 1816 Central Parkway, Cincinnati, Ohio, is engineer.

Okla., Ponca City—Continental Oil Co. plans installation of power equipment in connection with expansion and improvements in local oil refining plant. Entire project will cost close to $1,500,000. Work will begin soon. Main offices of company are at 60 East Forty-second Street, New York, N. Y.

Pa., Harrisburg—Pennsylvania Power & Light Co., Allentown, Pa., plans expansion and improvements in steam-electric generating station at Harrisburg, including installation of new 10,000-kw. turbine-generator unit, two high-pressure boilers and auxiliary equipment. Company also will make extensions in transmission lines in same district. Entire project will cost about $3,000,000.

Pa., Pittsburgh—American Textile Co., 815 Penn Avenue, plans installation of electric power equipment in new two-story mill, 120x312 ft., at Carson and War Streets. Entire project will cost over $100,000. C. A. Lake, 505 Second Avenue, is architect.

Pa., Pittsburgh—United States Engineer Office, New Post Office Building, will receive bids until Nov. 9 for one needle valve, complete with operating stand, drain valves, fittings, piping, etc. (Circular 279).

S. D., Buffalo—Buffalo Light & Power Co., has approved plans for new power plant on local site, using Diesel engine-generator unit, and will proceed with work at early date.

Texas, Luling—Luling Foundation has plans under way for new cold storage and refrigerating plant, with locker system. An existing building has been acquired and will be remodeled and equipped for plant. Cost reported over $35,000, with equipment. Morris, Noonan & Wilson, Builders' Exchange Building, are architects; L. D. Royer, Smith-Young Tower Building, is engineer, both San Antonio, Texas.

Va., Front Royal—American Viscose Corporation, 200 Madison Avenue, New York, N. Y., plans installation of electric power equipment in new additions to rayon mill at Front Royal for increased staple fiber production. Cost reported over $2,500,000. Completion is scheduled next summer.

Wis., Milwaukee—Chicago, Milwaukee, St. Paul & Pacific Railway Co., Union Station, Chicago, Ill., plans installation of power equipment, conveying apparatus and other mechanical equipment for extensions and improvements in car wheel shops at West Milwaukee. Work will begin soon. Entire project will cost over $100,000. Fred M. Sloane, first noted address, is division engineer.